AWI/94-008

AD-A286 544

ANS Based Submarine Simulation

Final Report

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Abstract

This document is the final report for ARPA contract MDA972-93-C-0044, which is to develop an ANS (Artificial Neural System) capable of modeling submarine performance based on full scale data generated using a computer based simulation program.

This report discusses the project background, including the requirements of such a simulation model, and the advantages of an ANS approach. The uniqueness of AWI's Optimal-Entropy Neural Network algorithm is discussed as well as its significance to the success of this project. AWI has developed an ANS to model submarine performance based on the setting of the input parameters to result in a particular performance for the submarine where the ANS specifies the position and orientation of the submarine sometime in the future. AWI has also developed an algorithm to run the ANS in the inverse mode, namely the algorithm allows the user to specify the desired position and orientation of the submarine at some time in the future, where the ANS will then specify the controlling input parameters to reach that specified objective. The latter specifications have to be within the realm of possible requirements or else the ANS will specify a possible solution close to what was desired. The developed ANS is capable of operating in a PC environment. The results are obtained almost instantaneously on the PC.

AWI

AMERICAN WELDING INSTITUTE

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October 5, 1994

Mr. Gary Jones
ARPA/MSTO
3701 North Fairfax Drive
Arlington, VA 22203-1714

Re: Contract Number MDA972-93-C-0044
AWI Project No. 3115

Dear Gary,

Enclosed is the final report for ANS based submarine simulation program. This report should replace the draft final report given to you earlier. As discussed, this final version is being sent after the deadline in order to include the results of the additional neural network training which was conducted through the end of September. Also enclosed is the runtime version of the software with instructions. If you have any questions about the software or if you would like to discuss the report, please call me.

Sincerely,

Hans Vanderveldt

Hans Vanderveldt
President

jb

Enclosures

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Acknowledgment

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Introduction

The Development of accurate simulation models of submarine behavior has been a matter of vital interest to the Navy for many years. Simulation models are used before a ship is built to evaluate alternative designs, estimate the submerged operating envelope (SOE), and train prospective crews. Subsequent to ship deployment, simulation models are used to continue crew training and to investigate possible anomalous behavior observed at sea.

Despite this long interest in the building of accurate predictive models, the history of submarine simulation has not always been satisfying in terms of a basic understanding of the physical phenomenon underlying observed behavior. The first really organized approach to developing equations of motion for U.S. submarines was the now famous "2510" report developed by Gertler and Hagen at DTRC in 1967. These equations were based on the assumption that all relevant parameters would be obtained by curve fitting the results of static simple oscillatory measurements for various forces and moments as a model is moved at constant speed. As a result, these equations are little more than a Taylor series expansion of the resulting forces and moments with certain slightly different forms for the power series expansion. For example, terms in X^3 are replaced with terms in $x|x|$.

In the early-70's, the Radio Controlled Model (RCM) was developed at DTRC. This provided a significant breakthrough in terms of model testing because the model was no longer artificially constrained. Even more importantly, actual full-scale maneuvers, such as stern plane jams, could be simulated. Use of the RCM permitted direct prediction of submarine motions, particularly during high-speed operations that would have been difficult or dangerous to conduct under full-scale conditions. The RCM was, and is, expensive to run and there are certain limitations in maneuvering potential because of the size of the MASK (Maneuver and Sea Keeping basin) at DTRC.

In the late 1970's, the potential for the use of parameter estimation and system identification (SI), which grew out of optimal control theory, was explored. SI techniques were developed at DTRC and to this day a combination of fixed model tests, RCM, and SI are the mainstays of simulation development of submarine motions in the U.S. Navy.

However, as important and useful as the techniques discussed above have been, the results do not contribute to an understanding of the hydrodynamics of submarine behavior. In addition, SI application remains more of an "art form" as opposed to a scientific methodology. Further, the early promise that SI would lead not only to a more precise method of "curve fitting", but to insights into hydraulic responses remains unfulfilled. As an example, the observed

pitch/depth oscillations that occur in the OHIO Class submarines during high speed turns is simulated by turning on a sine wave pitch and depth disturbance.

Current research efforts, primarily sponsored by ARPA's Sub Tech program have lead to the establishment of a Computational Fluid Dynamics Laboratory at DTRC. This laboratory has, as one of its primary goals, the development of methodologies which will permit the prediction of a submarine performance from basic design information. Attainment of that goal is still in the future and currently it continues to be necessary to utilize RCM, fixed-model testing, and SI methodologies despite their limitations.

Artificial Neural System (ANS) has proven to be a successful approach to real-time process modeling. However, traditional ANS training algorithms, such as back-propagation are time consuming. Learning instabilities and the determination of the optimal net configuration are other time consuming problems associated with traditional training algorithms.

Advantages of the AWI's ANS

Compared with conventional modeling techniques, the AWI ANS modeling approach has the following advantages:

- Empirically based. The ANS model relies solely on experimental or numerical data which is used as the training data for the ANS model.
- Real-time. The ANS model, in the forward mode, is capable of running in real time, even on an ordinary MS-DOS based machine.
- Near real-time inverse. Not only can the ANS model predict the future submarine trajectory when given the current condition and control variables, such as the position of rudder, stern planes and forward planes, but AWI's ANS also can determine the necessary control variables to lead the submarine to an operator specified position at some future time. In the inverse mode the ANS is capable of operating in near-real time on an MS-DOS based machine.

To overcome the problems associated with the traditional ANS training algorithms, AWI developed a proprietary training algorithm called the Optimized Entropy algorithm. This algorithm considers the delta error (the mean error of the net), as well as the "Entropy," as the driving forces of the net. In traditional training algorithms the mean error is the only driving force; this rule is called the "Delta Rule." AWI researchers have found that there is another driving force that we call "Entropy." The entropy, or lack thereof, is the major reason for learning instabilities, such as local minimum. This is accentuated when learning rates are maximized. By using the Optimized Entropy rule, AWI has reduced the

time required for the net to converge, and increased the efficiency of the net through the elimination of unessential nodes and links.

The unique significance of this system is the use of a new neural network training algorithm, called the "Optimized Entropy" algorithm, to train the neural network. This algorithm can accelerate the network learning process, overcome learning instabilities, and optimize the net configuration. The Optimized Entropy algorithm enables the solutions to difficult problems on a desktop computer within an acceptable time frame.

Objectives for the current work

The objective for this project is to show the feasibility of using a PC based ANS to model the submarine trajectory as the function of submarine speed, the position of the rudder, the stern planes, and forward planes and the control planes' holding time. The training data used in this project is obtained from a computer based simulation program supplied by Dr. John Ware at Computer Sciences Corporation (CSC). There are two reasons to use simulated data instead of actual operational data. First, the simulated data is unclassified. Second, if the ANS can simulate the simulation program, it is reasonable to believe that the ANS also can simulate the operational data. The ability to model the simulated data will prove the feasibility of using the PC based ANS, and therefore satisfy the objective of the program.

Artificial Neural Systems

Artificial Neural Systems (ANS) are loosely based on biological neural networks and offer a computer technology that is a useful tool in process modeling and signal processing. The ANS consists of a series of nodes (neurons) and weighted connections (axons). As with a biological neural network, the assignment of the values of the weights and the size and configuration of the network is the key to a successful net. Unfortunately, we have only begun to understand the inner workings of these constructs. Consequently, relatively unsophisticated tools are currently employed to develop working networks.

Traditionally the approach to model development is to gain a thorough understanding of the underlying scientific or engineering principles of the process. A model is then developed that is based on mathematical relationships inherent in the process parameters. The principal drawback with this approach is the time and effort required to develop an understanding of these basic scientific or engineering relationships. Depending on the complexity of the problem, it can take many years and an extensive research program to develop the relationships. Often, instead, a number of simplifying assumptions are made and an approximate model is developed. That approach, while being an expeditious method for developing an approximate model that could be useful, provides only a theoretical approximation that may not be valid for the actual problem application. With the existing modern computers it is also frequently

possible to develop computer based numerical solutions. However the generation of solutions using numerical analysis on-line are often too time-consuming to be useful for real time analysis.

The ANS, when a network can be found to solve the problem, provides an accurate model of the process or signal. Neural networks are empirically based systems that, when presented with a specific input pattern, can associate specific output patterns. It is, essentially, a highly complex, non-linear, mathematical relationship or transform. However; it is not necessary for the developer of such a system to understand the basic underlying principles of a process in order to develop a highly accurate ANS based model of the process. Thus, in this way it is quite different from other mathematical modeling or signal processing approaches.

Basic Principles

The problem of an ANS is to decide how many nodes and connections are needed to model a specific problem; to decide how to configure them; and to decide the specific values of the connection weights and the transfer functions that exist within the network. Figure 1 represents a schematic diagram of a neural network and Figure 2 is a representation of the weights, transfer functions, and the mechanisms of network operation. There is no direct known correspondence between the network parameters, its operation, and the problem to be modeled by the network. As a consequence, there are currently a lack of good mechanisms that can be used to directly assign the weights and transfer functions in the network so that it can solve a problem. The methodology of finding a proper net configuration and weights to model a given problem is to step through a series of searches to find the optimum solution. This process is called "Learning." There are many learning algorithms that have been developed[1]. They all have some advantages and restrictions. In the modeling and signal processing areas, the back-propagation method is the most popular.

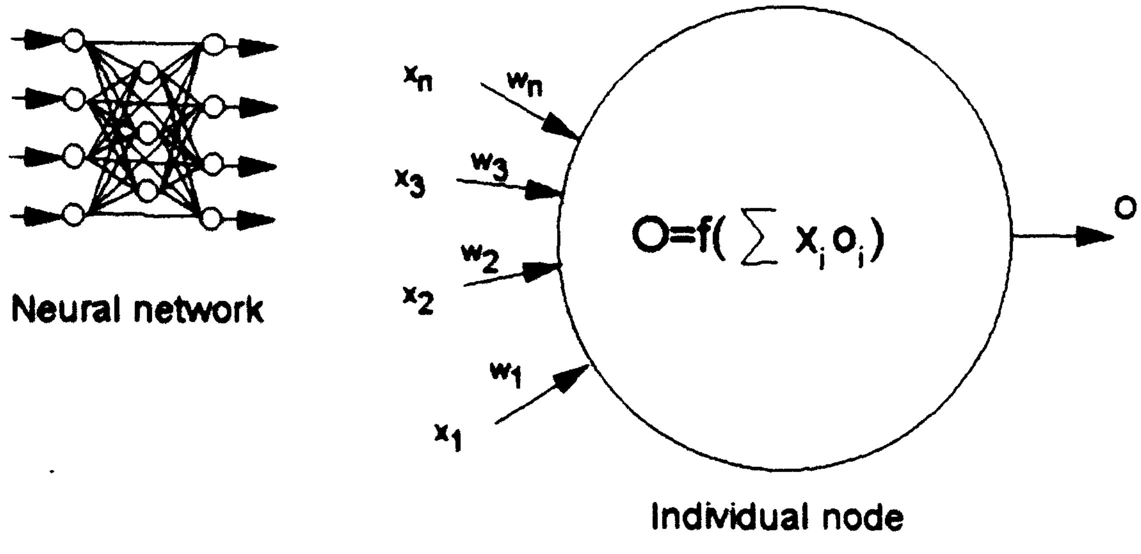

Figure 2 Schematic Representation of a Neural Network Node

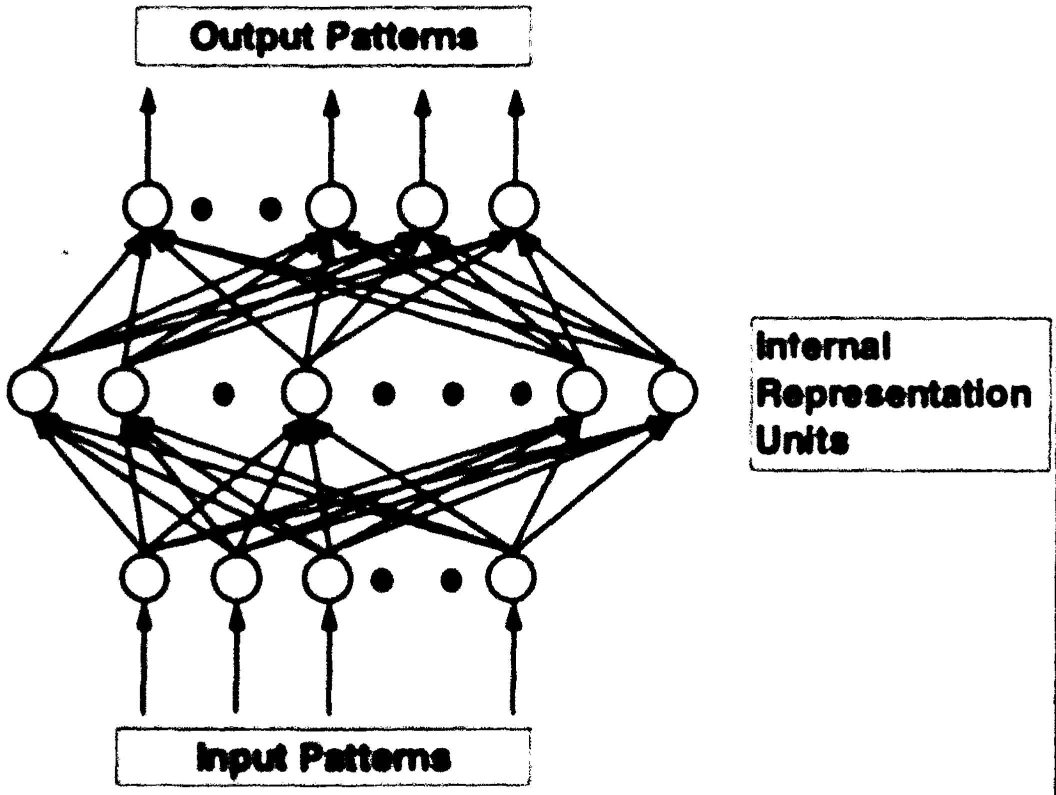

Figure 1 Schematic Diagram of a Neural Network

Back Propagation

The back propagation method assumes that the search in weight space for an optimum, or near optimum, network configuration can be accomplished as an iterative search using the error gradient, i.e., slope of the error surface in L_2 space[2a]. That is, a series of moves are accomplished on the multiple-dimensional error surface using approximately the maximum mean squared error gradient direction as the move direction at each iteration. The error, also called the delta, in the network is defined as the mean squared error between the desired output representation and the actual output given the current weight matrix values of the current net. By calculating the maximum gradient of the delta for any given training example (set of input and corresponding output patterns), the weights are adjusted so that the net moves along that gradient direction in each presentation of the training example to the network[3]. Using this procedure, the network slowly "learns" to associate all of the training example input patterns with the correct corresponding output patterns by finding a global minimum on the error surface. Since the primary driving force in the back-propagation method is the mean squared error -- delta, it also called the "delta rule."

This "basic" back propagation learning process has several significant drawbacks. First, the optimum configuration, i.e., number and relative location of hidden representation units or nodes cannot be pre-determined and, yet, needs to be pre-assigned by using an "educated guess" in order to use this procedure. Since the node configuration can significantly affect the operation of the network, this w i at best lead to a long series of re-tries and, at worse, to no useful network at all. Second, this process is very slow and the learning rate (a constant to define the search step size) is set arbitrarily, traditionally at a value between zero and one. Even though research is being conducted, no current known method for predetermining the learning rate (gain term) will consistently choose an optimum value, and the optimum value is significantly influenced by the specific problem being presented to the network. Third, it has been shown

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[a] L_m space is defined as

$$L_m = (R^n, d_m)$$

here R is a real number set, therefore R^n is the vector set,

$$R^n = \{(x_1, x_2, \ldots x_n) \mid xi \in R\}$$

The distance function d_m, is defined as

$$d_m((x_1, x_2, \ldots, x_n), (y_1, y_2, \ldots, y_n)) = ((/x1-y1/)^m + (/x2-y2/)^m + \ldots + (/x_n-y_n/)^m)^{1/m}$$

where $1 <= m <= \infty$. It can be easily proven that when m approach infinity,

$$L_\infty = \max /x_i - y_i/$$

Mathematically, the L_m space is a matrix space. Most common used L_m spaces are: L_1, L_2, and L_∞.

In this application L_2 space is used and n is equal to the num er of desired outputs. The distance function d_2 is used to determine the error or error gradient--the difference in desired and actual outputs. The error determined by d_2 is also called the mean square error.

that it generally requires a larger network to "learn" a problem than is required to solve the problem. Considering the many studies, it is generally known that the net could be trimmed to a smaller size. However, there is no known method of reducing the size of the network optimally after training to optimize the net performance. Finally, learning instabilities exist in many problems that will cause the network to stop learning (converging). One of these instability types is known as a local minimum. A local minimum is a depression in the error surface, but one that is not the optimum minimum or lowest error position. In its search routine, the network algorithm may fall into a local minimum and since the error gradient is toward the local minimum from all directions, may not be able to exit from it.

The Optimized Entropy Network

A proprietary method developed at AWI for training neural networks has been shown to overcome all of the known problems with the back-propagation method, while maintaining the inherent stability and known network development capabilities of that method. This network was developed through the use of a thermodynamic model of the network operation that included both the delta energy, the kinetics of the network and optimization functions. The technique, known as the Optimized Entropy Network (O-E Net), has been used on several applications ranging from high speed signal processing to vision systems.

At the American Welding Institute researchers have studied the learning behaviors of artificial neural networks for several years. Based on the thermodynamic and kinetic model of the learning, it was discovered that the learning is not only driven by the delta, but also by another important factor—the entropy, which is defined as the driving forces of the net. The entropy is a kinetic measurement about how well the neural network is learning at certain stages of the training. Sometimes, even if the delta is large but entropy is low, the system will not learn. This is the case when the system reaches a local minimum or other kind of learning instability. Additionally, the mathematical functions used for the training of the ANS have been optimized as well. The optimized entropy algorithm will monitor the entropy closely during the learning, maintaining a reasonable entropy while pushing the learning rate as high as possible using the optimized mathematical functions.

The O-E Net has achieved learning rates greater than 1000 times that of the standard back propagation method for complex problems while also preventing the network from falling into learning instabilities. Research conducted by the AJI researchers has confirmed the existence of at least three types of learning instabilities (local minimum, trough and flat surface) and the O-E Net algorithm can avoid all three instabilities. In addition, using entropy as the critical driving force, the system configures itself dynamically during the learning process and so it can produce a near optimum network size for operation, often much smaller than the network needed to "learn" the problem.

Developmental Procedures

The steps and processes used in the development of the ANS for this project are described in detail in the following sections.

Implementation Scheme

For this feasibility study, it was decided to model the submarine trajectory over a 1000 second time frame. There are four measurements related to the submarine trajectory: Depth (in feet), Pitch (in degrees), Heading (in degrees), and Roll (in degrees). The control variables are:

- The speed of the submarine, from 2 knots to 15 knots.
- The angle of the stern plane, from -15 degrees to +15 degrees.
- The angle of the rudder plane, from -15 degrees to +15 degrees.
- The angle of the forward plane, from -15 degrees to +15 degrees.
- The planes' holding time before returning back to the neutral position, from 10 seconds to 100 seconds.

Two sets of data are required to train a neural network: a training data set and a testing data set. The training data set contains the data which is presented to the neural network for training, i.e. development of the ANS structure needed for identification of the desired features in the data set. The testing data is used to test the performance and accuracy of the trained neural networks. To verify the accuracy of the final ANS, the test data set contains all combinations of the following data points, also known as via points:

- Speed: 2, 2.5, 3, 3.5, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 15 knots.
- Stern plane: -15, -12, -9, -6, -3, 0, +3, +6, +9, +12, and +15 degrees.
- Rudder plane: -15, -12, -9, -6, -3, 0, +3, +6, +9, +12, and +15 degrees.
- Forward plane: -15, -12, -9, -6, -3, 0, +3, +6, +9, +12, and +15 degrees.
- Holding Time: 10, 20, 35, 50, 65, 80, and 100 sec.

Therefore there are a total of 15x11x11x11x7=139,755 test data samples.

The O-E algorithm will automatically determine the training samples as necessary during the training process. The final training samples are listed in Table 2 in the Training section and Appendix B. Both test and training data samples are produced by the simulation program supplied by Dr. John.

Experience has lead AWI to develop multiple-output networks by training a net for each trajectory measurement individually and then combining each net into one final ANS. Arithmetically there are no differences, only savings in the total training time that would otherwise be needed. Another advantage is the ability

to easily add new types of output at a later time. To further reduce the required training time and size of the net, each individual neural network works only within a certain speed range: low speed (2 to 5 knots), medium speed (5 to 10 knots), or high speed (10 to 15 knots). Therefore, there are a total of 12 individual neural networks which have been developed. Table 1 lists the names of each individual net and its working domain.

Table 1. Neural Networks Developed For this Project

	Depth	Pitch	Heading	Roll
Low Speed (2-5 Knots)	SUB11.NET	SUB12.NET	SUB13.NET	SUB14.NET
Medium Speed (5-10 Knots)	SUB21.NET	SUB22.NET	SUB23.NET	SUB24.NET
High Speed (10-15 Knots)	SUB31.NET	SUB32.NET	SUB33.NET	SUB34.NET

Although 12 individual neural networks are contained in the system, they are fully integrated together as a whole through the runtime user interface. Hence the user only "sees" one ANS.

Graphical User Interface

Two graphical user interfaces were developed for this project. One of the user interfaces was only used for training and testing the individual nets. Another graphical user interface (GUI) was developed for use with the runtime ANS, which combines all twelve nets into one. Both interfaces were developed using the C++ programming language. They are menu driven graphic interfaces which use an AWI proprietary GUI management tool called "WIN." Both interfaces can be run on either an IBM RS6000 UNIX workstation or a DOS based IBM personal computer. To reduce the training time, most of training and testing was done on an RS6000 workstation.

Implementation and Training Interface

The input to one individual network consists of the speed, stern plane angle, rudder angle, forward plane angle and the hold time for the control surfaces. There are a total of 78 output nodes for each individual neural network which is logarithmically distributed in the 1000 second time frame (Figure 3). Obviously, the manner of choosing the proper number of output data points and their distribution has lot to do with the accuracy and training time. Several schemes were tested, including the exponential distribution, linear distribution, and logarithmic distribution combined with different numbers of output nodes from 50 to 100. The 78 output nodes with a logarithmic distribution is the best combination based on experience and is chosen as the final configuration.

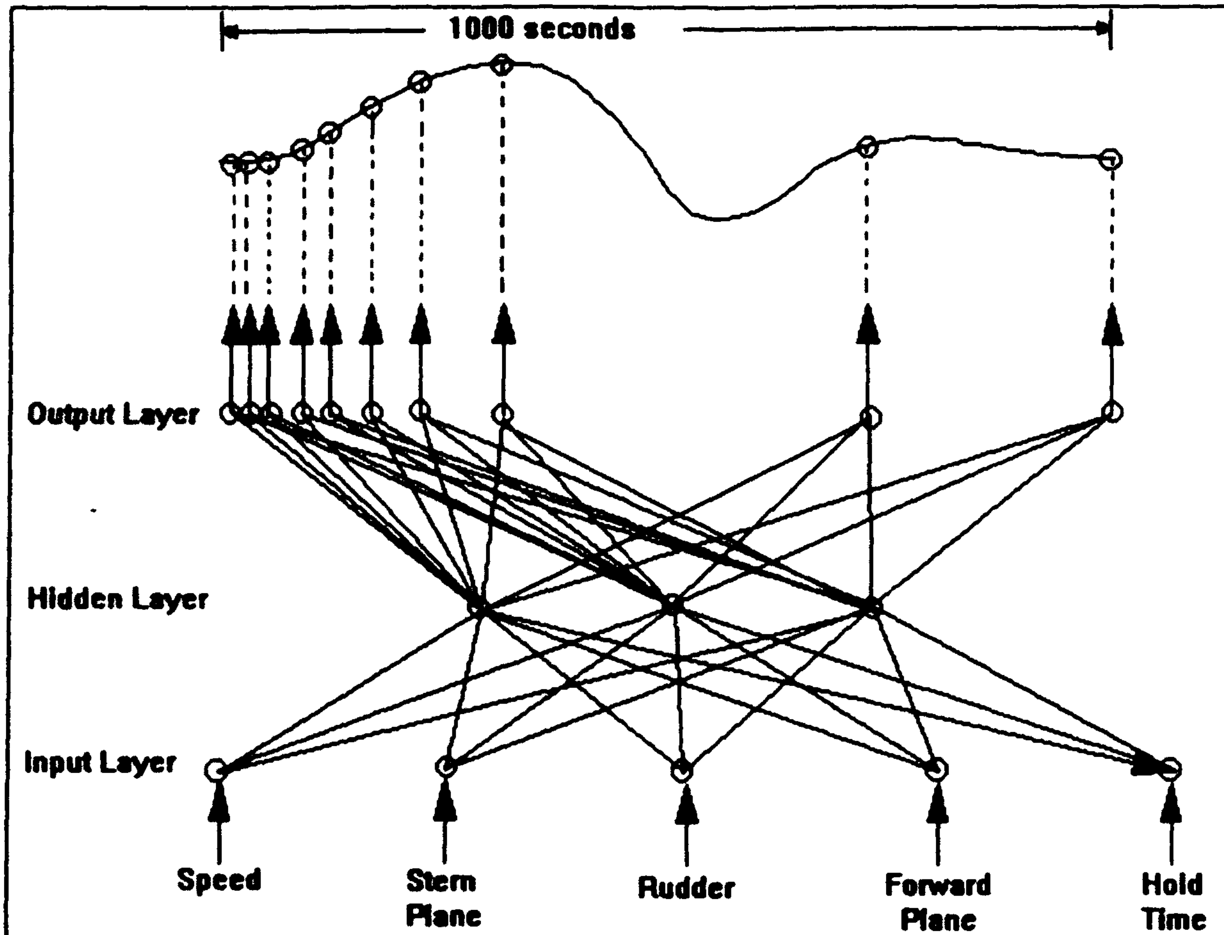


Figure 3 Schematic Presentation of Inputs and Outputs of the Network

The training GUI developed by AWI is a generic user-friendly interface (Figure 4). This interface is written in the C++ programming language and can run on an IBM-or compatible PC and an RS 6000 workstation without code modification. Using this interface, the training and testing can be done in an "automatic" or "manual" manner. The training files and training data are easily accessible through the GUI. The user can easily adjust the training parameters manually, such as the learning rate, net configuration, input/output distribution functions, and weights.

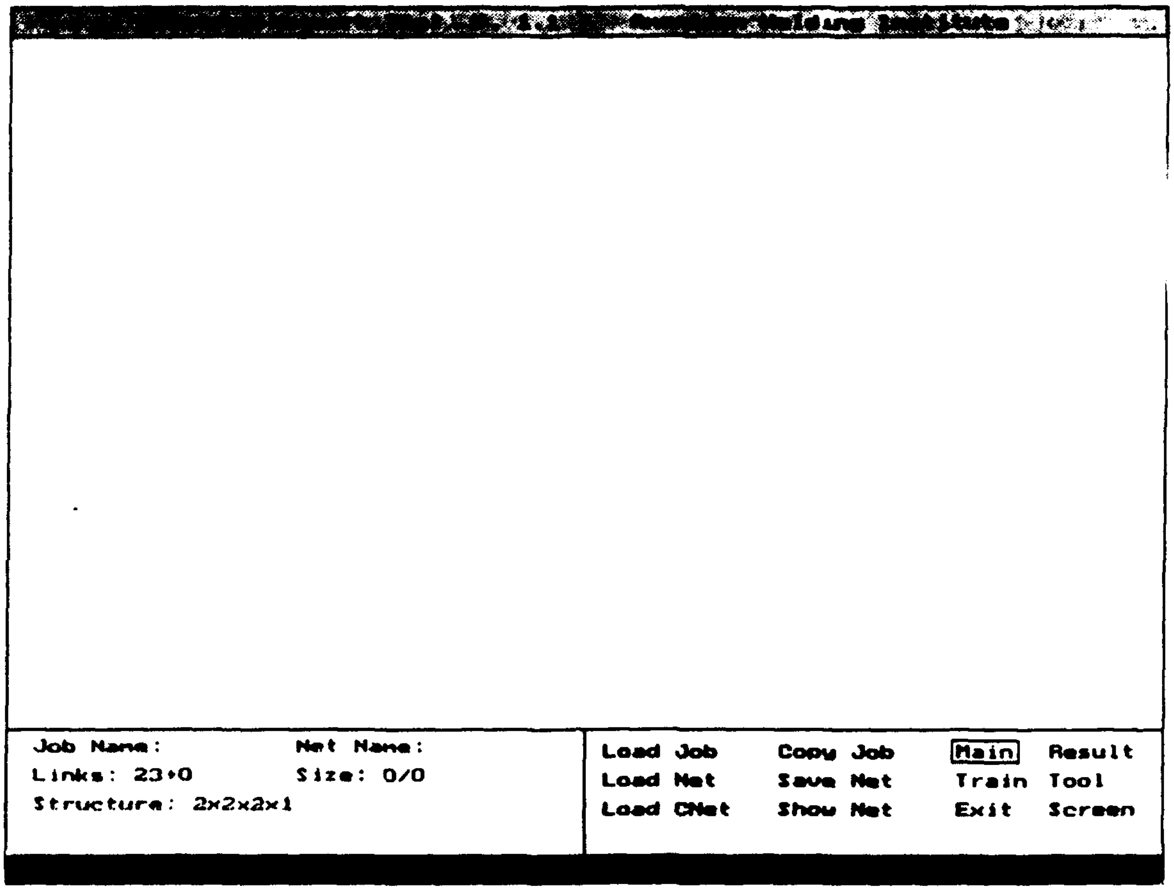
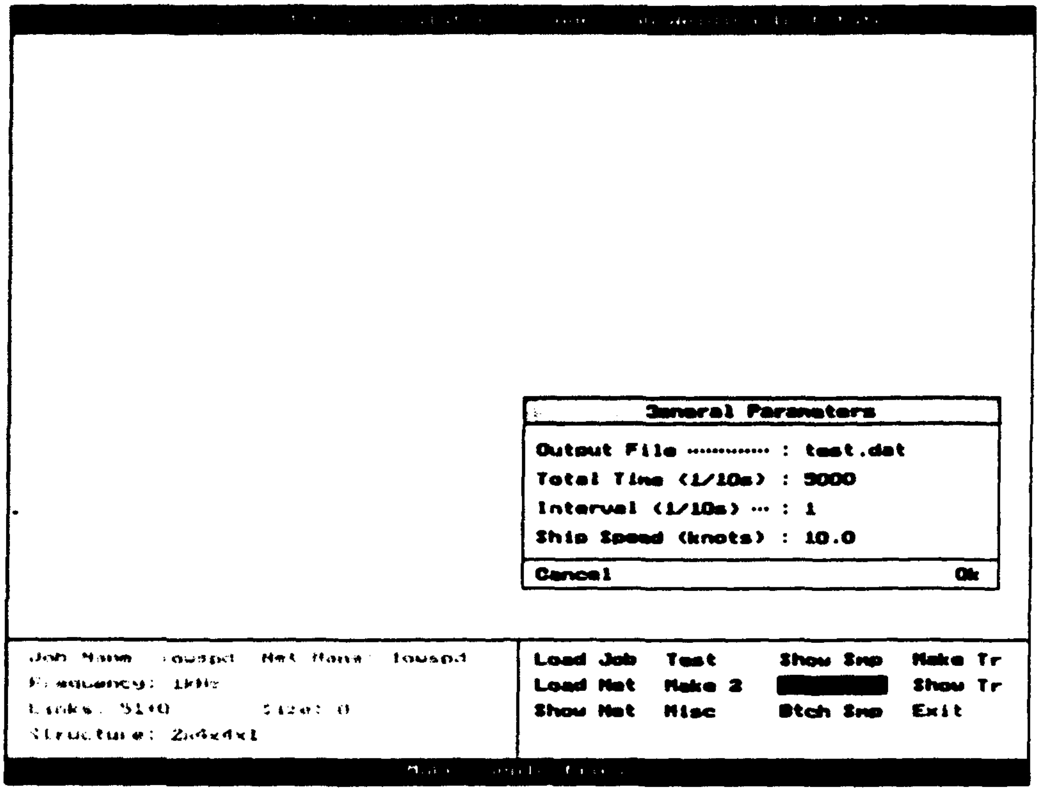


Figure 4. The Training Interface

This interface also allows the generation of the training and testing samples using the numerical simulation program, which is a non-GUI program. The data can be generated randomly or automatically. For random generation, the user can type in variables such as the time and angle of each control plane through the GUI (Figure 5), then the GUI will cause the simulation program to calculate the results. The results can then be displayed graphically on the screen (Figure 6). For automatic data generation, the user can specify the via points of each variable, then the GUI will automatically generate all samples on the grid and store them on the hard disk. Another button on the GUI allows the user to convert this data into a format which can be directly used for training and testing purposes (see Figure 6).



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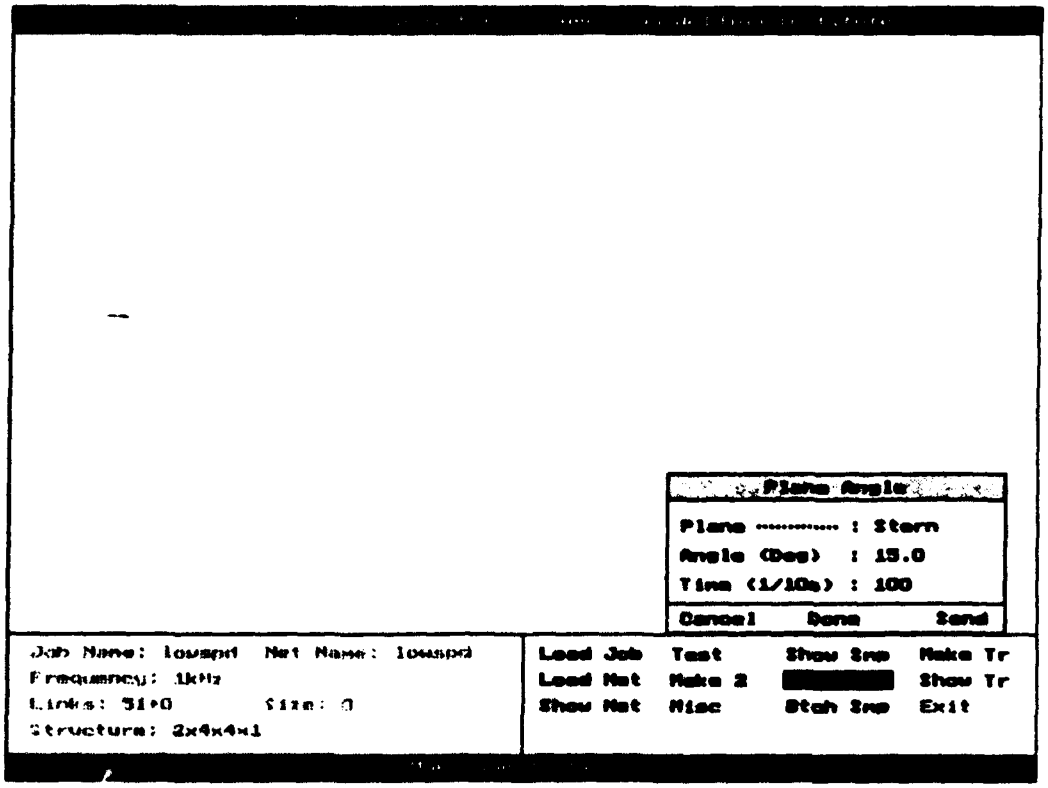


(5b)

Figure 5 Sample File Generation

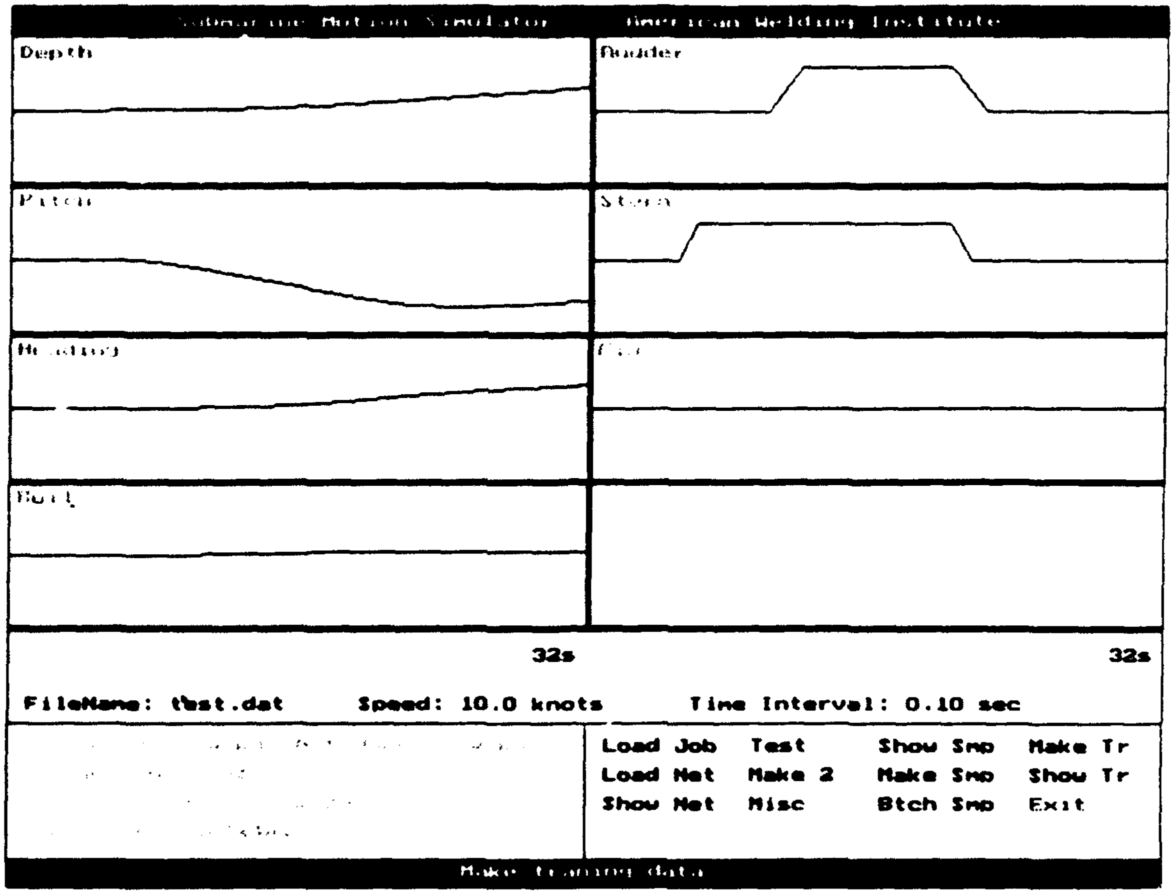


Figure 6 The Sample Generated by the Numerical Computation

As previously mentioned, AWI has trained twelve individual nets, each of which is responsible for performing one measurement of the submarine trajectory in one speed range. For each net, there is a job file and a training file associated with the training process. Therefore, for the problem discussed herein, there are twelve job files and twelve training files. The job file contains the general information of the trained net, such as the number of input and output nodes, and the distribution scheme of the output nodes. The training file contains all training and testing file names. Each time, the GUI can only train and test a single job. By using the "Load Job" button, various jobs can be loaded into the GUI for training and testing.

Trial Training

As previously discussed, two very important factors must first be determined, which are the number of output nodes and the distribution scheme of these nodes in the 1000 second time frame. Using the training interface, a series of rough trial training runs are conducted to determine the optimum number of output nodes and the distribution scheme. The objective of a trial training is to train the net to within a 20% error level with various combination of output nodes

and distribution schemes. The testing range for the number of output nodes is from 50 to 100. The distribution functions used in the test are the linear, exponential, and logarithmic. The optimum combination is determined based on the number of training cycles and the overall time needed for each trial net to converge. Based on the results from these trial trainings, a 78 output node network using logarithmic distribution was selected.

Training

As previously identified, the training was done individually for each measurement of the trajectory within certain speed range. Each individual training set was done in the following manner. Initial training of the net was performed with 10 randomly selected training samples. After the net converges, it is tested on all 139,755 testing samples. If the result is not satisfactory, the E-O algorithm will suggest the next training sample which needs to be added. Using the numerical simulation program, the designated sample will be generated and added into the training set automatically. The net will be retrained using this new training sample. This procedure will be repeated many times until the final testing result is satisfactory.

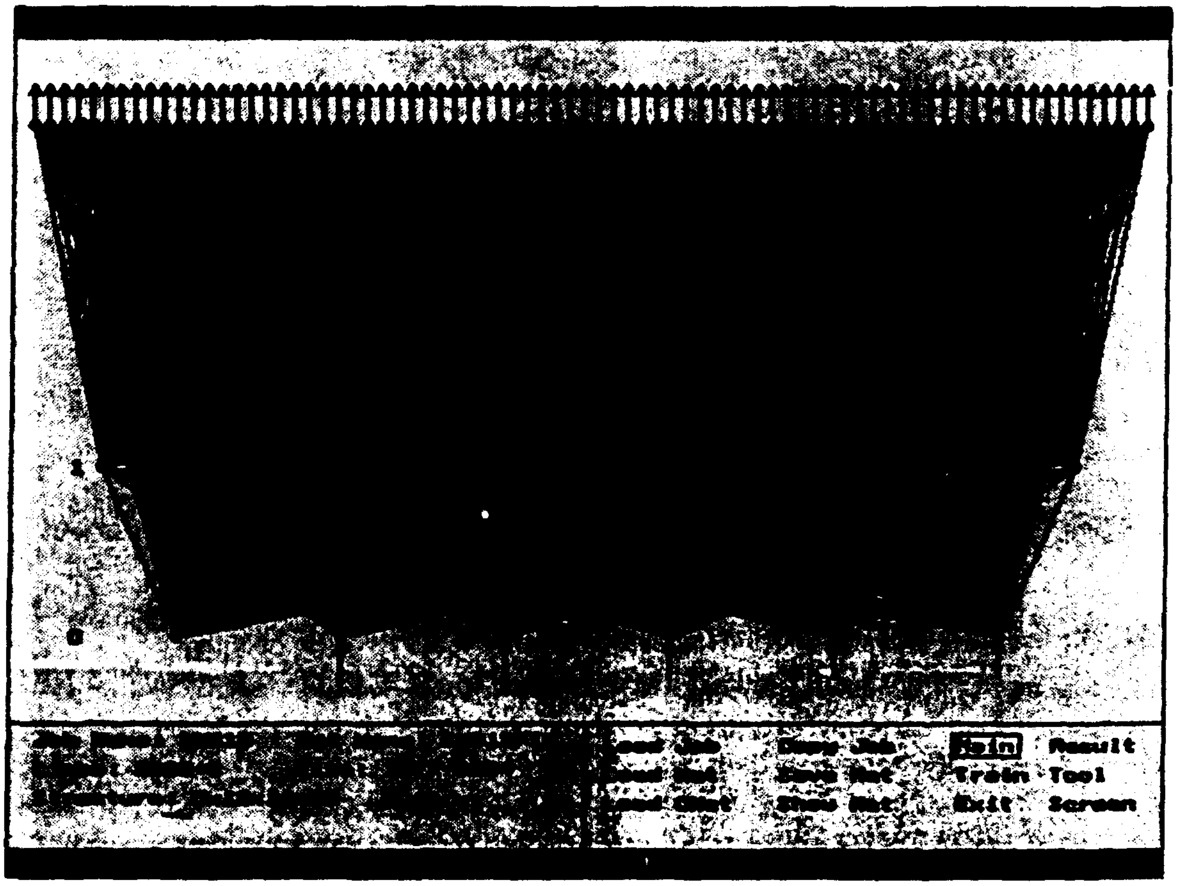
Through the training interface, the above procedure can be done automatically. Table 2 summarizes the number of training samples used by each individual net and Appendix B lists detailed information of all training samples used in the training.

Table 2 Number Of Training Samples Used By Each Net

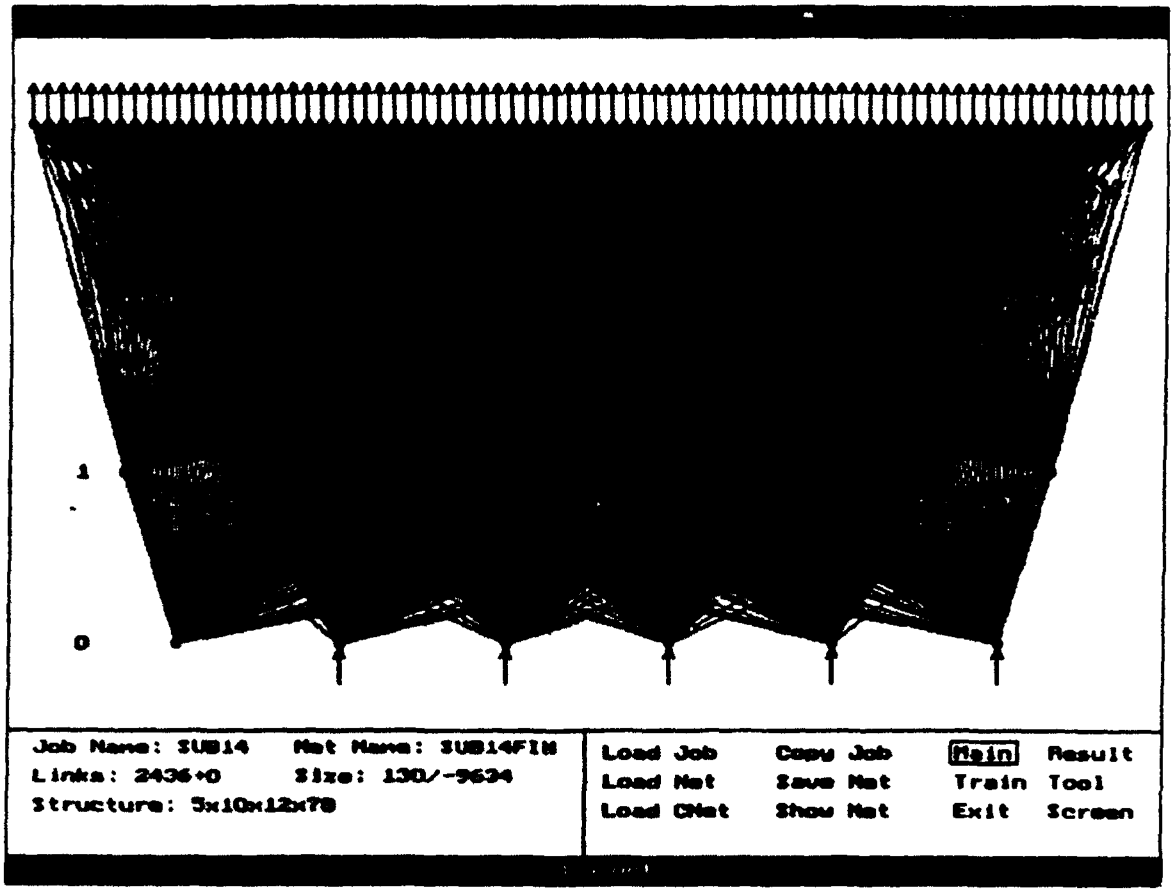
Net Name	**Number of training SAMPLES**
SUB11.NET	287
SUB12.NET	197
SUB13.NET	89
SUB14.NET	130
SUB21.NET	175
SUB22.NET	255
SUB23.NET	386
SUB24.NET	254
SUB31.NET	301
SUB32.NET	248
SUB33.NET	485
SUB34.NET	183

Even though there are 12 individual ANSs, there are some similarities. For example, the number of input nodes and output nodes for each ANS is the same. The differences lie in the number of hidden layers and nodes within those hidden layers. The optimization procedures of the Optimized Entropy rule yield

individual representations. Figures 7 shows schematic representations of two ANSs thus configured. The SUB12 has 5 input nodes, 78 output nodes, and two hidden layers of twelve and fourteen nodes respectively. The SUB14 has the same input and output nodes, yet it consists of two hidden layers of ten and twelve nodes respectively. This latter ANS structure is designated as 5x12x11x78. Table 3 summarizes the net configuration for each individual neural network.



(7a) SUB12.NET



(7b) SUB14.NET

Figure 7 The neural network configuration for SUB12.NET and SUB14.NET

Table 3 Net Configuration for Each Net

Net Name	Configuration	Number Of Links
SUB11.NET	5x12x15x78	2916
SUB12.NET	5x12x14x78	2820
SUB13.NET	5x12x14x78	2820
SUB14.NET	5x10x12x78	2436
SUB21.NET	5x12x14x78	2820
SUB22.NET	5x12x12x78	2628
SUB23.NET	5x12x14x78	2820
SUB24.NET	5x12x11x78	2532
SUB31.NET	5x14x13x78	2918
SUB32.NET	5x10x11x78	2342
SUB33.NET	5x15x15x78	3213
SUB34.NET	5x11x14x78	2722
Summary	5x144x159x78	32987

Testing

There are two types of testing, namely: automatic and random. In the automatic mode, the program will automatically test the current net through the entire 139,755 test data and record the maximum error, mean error, and other useful statistical results into a file (see Appendix A) and/or display the results on the screen (Figure 8). In Figure 8 the results should be read as follows. Each horizontal plot (there are 8 such plots in the Figure) shows the sample number in the upper left box, below that the maximum error for that sample and below that the mean error for that sample when the computer generated results and the ANS generated results are compared. Looking at the plotted values, the first five lines represent the input parameters, the next 78 data points are the values generated by CSC's simulation program and the last 78 data points are those determined by the ANS for that sample. In the random testing mode, the user can specify the input of any value within the operating domain, and the output of the neural network will then be compared with the result of the numerical simulation program and the output curves will be plotted on the computer screen for comparison.

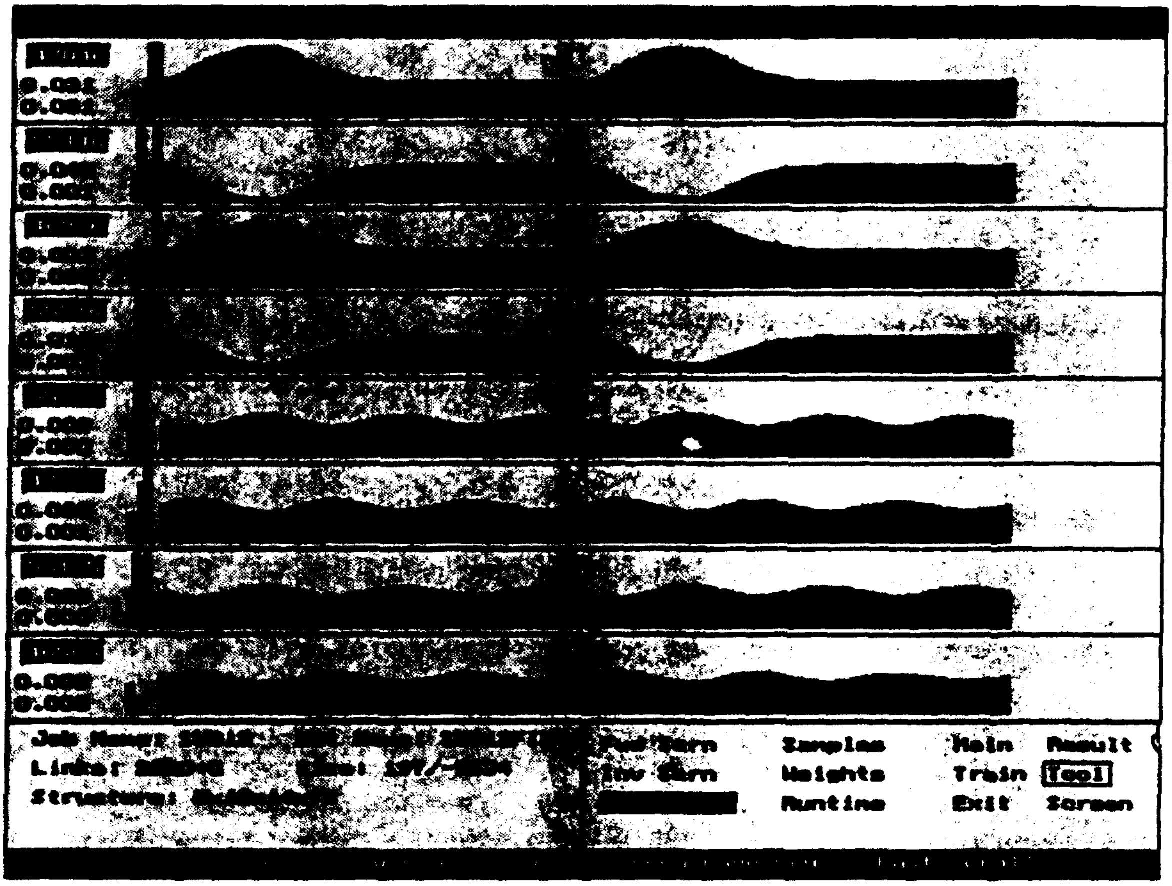


Figure 8. The testing result screen.

Runtime GUI and Combined Neural Net

The summation of each individual net in the final run-time configuration yields the same results as if the net were configured as a whole. The real benefits are in the saving of a great deal of development time and effort. Figure 9 shows the runtime GUI.

Figure 9 The runtime GUI

Results and Analysis

AWI has developed an ANS based submarine simulation with a maximum error over the entire domain of the ANS no larger than 7%. In most cases the actual error is significantly less. Table 4 summarizes these results for each ANS.

The maximum error, E is calculated by the following formula:

$$E=\max(|O_i-D_i|)/N$$

Here O_i is the actual output of the i^{th} node of the ANS and D_i is the desired value of the output node, where i runs from 1 to 78. N is the dynamic range of the output, which is listed in Table 5

Table 4 Final Results

Net Name	Maximum Error E
SUB11.NET	0.02
SUB12.NET	0.045
SUB13.NET	0.06
SUB14.NET	0.045
SUB21.NET	0.04
SUB22.NET	0.06
SUB23.NET	0.02
SUB24.NET	0.07
SUB31.NET	0.06
SUB32.NET	0.06
SUB33.NET	0.03
SUB34.NET	0.06

*Results are based on testing the developed ANS against 139,755 test data points.

Table 5 The Dynamic Range, N

Net Name	N
SUB11.NET	340
SUB12.NET	34
SUB13.NET	200
SUB14.NET	4
SUB21.NET	3000
SUB22.NET	100
SUB23.NET	300
SUB24.NET	8
SUB31.NET	8000
SUB32.NET	180
SUB33.NET	440
SUB34.NET	32

The system can be run in either forward or inverse mode. When the system is running in the forward mode, the screen will be similar to Figure 10. Moving the slide bars of each control variable causes the submarine trajectory to be calculated immediately and graphically displayed on the screen. Alternatively, the desired settings for the control variable can be input directly by highlighting and then typing the value in the box under the slide bar.

On the forward screen, the control variable, which is the input to the ANS is shown on the slide bar located on the bottom part of the screen. These bars can

be slid up or down using mouse. A additional slide called "Scale" is shown on the same screen as well. Moving this slide can change the output plot scale. The predicted submarine trajectory will graphically displayed on the top part of the screen, which are the depth, pitch, heading, and roll. The positive depth means the submarine goes down. The pitch, heading, and rolling angle in counterclockwise direction facing the bow of the submarine are positive.

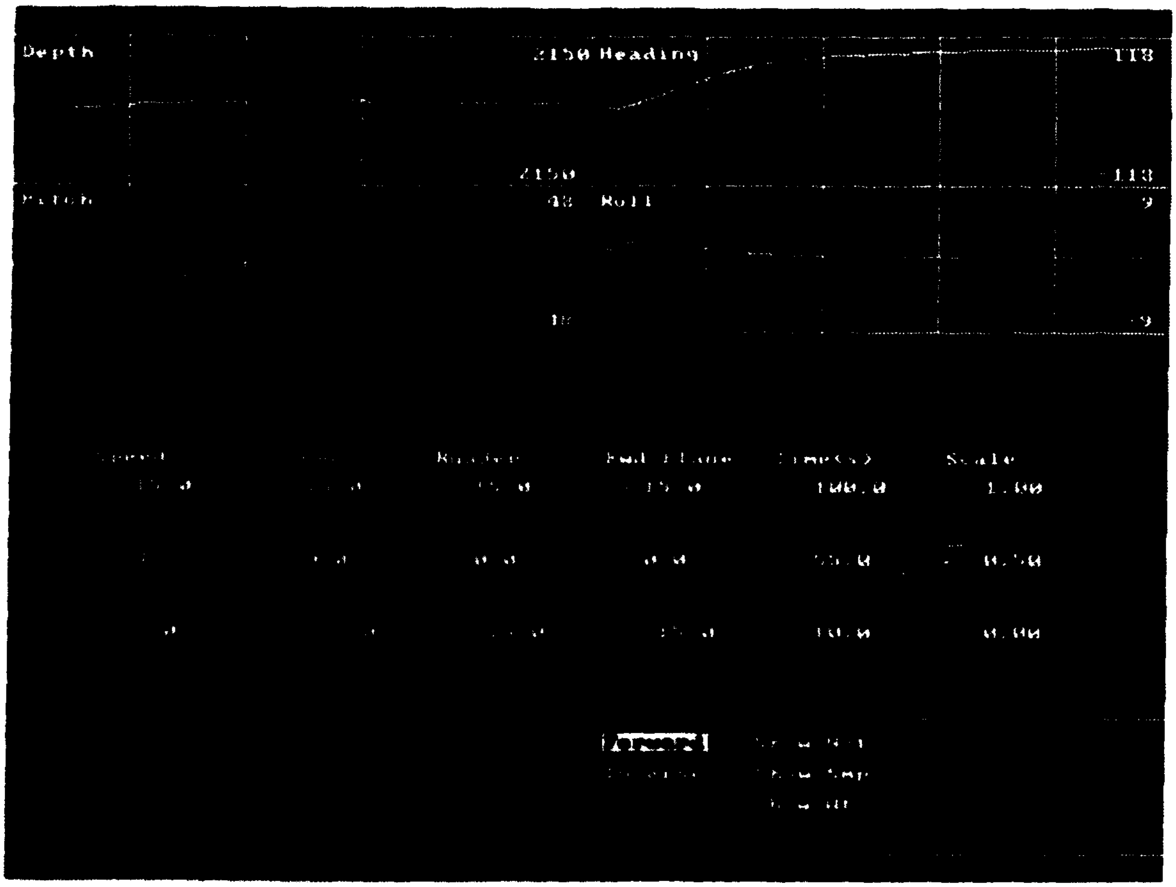


Figure 10 Running the system in forward mode on the runtime GUI

When the system runs in the inverse mode, the screen will be similar to Figure 11. The user can specify a point on the submarine trajectory at some time in the future. For example, the user can require that the submarine to be at a depth of 1500 feet, a heading of -30 degree, a pitch of 0 degrees and at a roll angle of 0 degrees relative to current position at a point in time 800 seconds later. Then the system will recommend the proper values for each control variable in order to lead the submarine to pass the desired point 800 seconds later as closely as possible (see Figure 12) assuming the user did not request an impossible condition. If the user did ask for the impossible, then the ANS still tries to match the request as closely as possible.

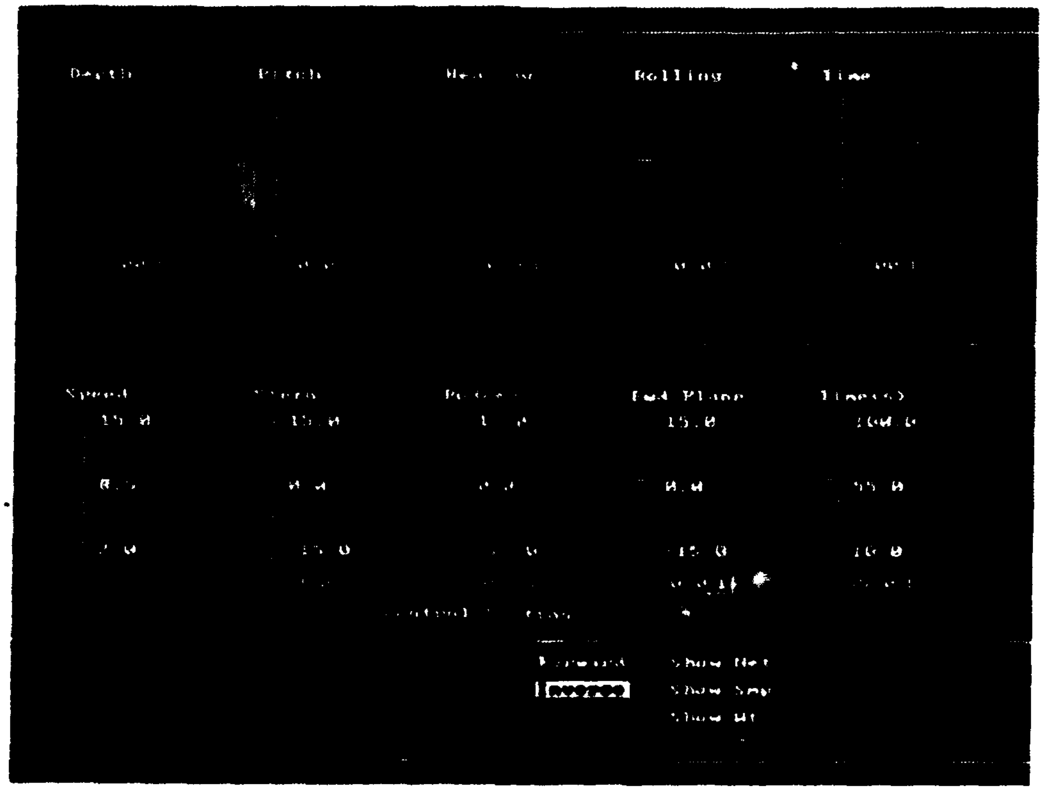


Figure 11 Running the system in the inverse mode on the runtime GUI

Figure 12. The inverse result.

When the system runs in the inverse mode, the control variables can be weighted in a range from 0 to 5. This weight represents the freedom to change a particular parameter. Weight 0 means no freedom at all, which simply means that this control variable cannot be changed. For example, if the speed is 12 knots and the weight for the speed is 0, the algorithm must keep the speed constant at 12 knots while attempting to vary other control variables, such as the angle of the stern plane, rudder, and forward plane, and hold time, so that the submarine can pass the required point at the required time as closely as possible. Weight 1 means this variable has least freedom, while weight 5 means this variable has the greatest freedom of change. The algorithm will attempt to adjust the variables which have the highest degree of freedom first, and the variable(s) with lowest degree of freedom last, if necessary.

Each individual measurement of the trajectory also has a weight associated with it when the system is running in the inverse mode. This weight controls how closely this measurement has to be matched. Weight 0 means it is not important at all while 5 indicates that it is the most important.

Running a neural network in the inverse mode represents a search problem which can be approached with a thorough search or a gradient search. The thorough search guarantees that the best possible answer will be found, but it is also very time consuming. The gradient search can save a great deal of time, but the local minimum (or local maximum) problem can occur and prevent the system from continuing to find the best solution. The O-E algorithm used in our ANS training is adapted to inverse searching and speeds up the search while it guarantees that it will find the global minimum solution. The entire search process only takes about 4 seconds on a 90 MHz Pentium PC.

Conclusions

AWI has successfully demonstrated the feasibility of modeling the submarine trajectory using ANS. Several advantages have been revealed through this study:

- Empirical based model can be developed without the use of human experts.
- The ANS model can be developed at a significantly lower cost than traditional modeling approaches.
- Requires less computing power to run the finished model which enables the forward system to run in real time on a conventional PC.
- Near real time inverse model has been developed, which can be used in a crew training system or an automatic control system. The inverse model can be developed to run in real time, although the current ANS takes 4 seconds to determine input parameters on a Pentium based PC.

Future Work

Several possible future steps are suggested:

- Apply AWI's proprietary ANS approach with real data instead of simulated data.
- Using a multiple processor workstation, train the ANS to a much higher accuracy.
- Apply the ANS as a training tool for submarine.

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Appendix A Test Results

Testing Result File (Partial)

Job:sub32

Net:sub32

Structure:5x10x11x78

Sample#	L1 Error	L2 Error
00000	0.009584	0.000445
00001	0.019626	0.000900
00002	0.026579	0.001497
00003	0.014546	0.000764
00004	0.023326	0.001140
00005	0.017296	0.000901
00006	0.052169	0.004012
00007	0.006562	0.000365
00008	0.020237	0.000951
00009	0.024025	0.001369
00010	0.015869	0.000823
00011	0.020226	0.000887
00012	0.019070	0.000981
00013	0.056834	0.003213
00014	0.007084	0.000364
00015	0.020039	0.000977
00016	0.021303	0.001238
00017	0.015842	0.000820
00018	0.015814	0.000599
00019	0.024821	0.001306
00020	0.047241	0.002730
00021	0.007489	0.000374
00022	0.019185	0.000974
00023	0.021592	0.001140
00024	0.014741	0.000773
00025	0.010912	0.000524
00026	0.031768	0.001723
00027	0.043140	0.002540
00028	0.007182	0.000372
00029	0.018025	0.000959
00030	0.023484	0.001125
00031	0.013500	0.000723
00032	0.012783	0.000625
00033	0.035759	0.001974
00034	0.040072	0.002383
00035	0.007059	0.000364
00036	0.017297	0.000957
00037	0.027556	0.001270
00038	0.012448	0.000696
00039	0.009491	0.000481
00040	0.030931	0.001694
00041	0.031909	0.001862
00042	0.007442	0.000361
00043	0.016151	0.000919
00044	0.034079	0.001597
00045	0.009477	0.000529
00046	0.011049	0.000535
00047	0.015504	0.000798
00048	0.020171	0.001072
00049	0.018038	0.000801
00050	0.017739	0.000843

00051	0.034067	0.001928	00087	0.011069	0.000541
00052	0.013553	0.000676	00088	0.008341	0.000424
00053	0.009227	0.000464	00089	0.018807	0.000959
00054	0.022963	0.001204	00090	0.010571	0.000519
00055	0.051995	0.002938	00091	0.013451	0.000638
00056	0.013935	0.000591	00092	0.014964	0.000779
00057	0.019675	0.000903	00093	0.036845	0.001926
00058	0.032220	0.001847	00094	0.021770	0.001060
00059	0.011371	0.000540	00095	0.010959	0.000472
00060	0.011556	0.000551	00096	0.017353	0.000519
00061	0.024061	0.001268	00097	0.013557	0.000579
00062	0.036316	0.002073	00098	0.020792	0.000876
00063	0.010664	0.000468	00099	0.021670	0.001012
00064	0.020723	0.000960	00100	0.040955	0.002251
00065	0.030113	0.001751	....		
00066	0.009914	0.000470			
00067	0.014988	0.000713	29489	0.014399	0.000625
00068	0.028057	0.001505	29490	0.022989	0.001168
00069	0.027938	0.001605	29491	0.013817	0.000839
00070	0.008654	0.000422	29492	0.018055	0.000959
00071	0.020918	0.000987	29493	0.022910	0.000985
00072	0.028201	0.001676	29494	0.028272	0.000925
00073	0.008853	0.000445	29495	0.012534	0.000533
00074	0.017677	0.000855	29496	0.014741	0.000637
00075	0.031658	0.001719	29497	0.023222	0.001109
00076	0.024126	0.001382	29498	0.041649	0.001941
00077	0.007950	0.000410	29499	0.038827	0.002115
00078	0.020584	0.000987	29500	0.043788	0.002066
00079	0.029925	0.001694	29501	0.038054	0.001601
00080	0.007899	0.000445	29502	0.025421	0.000946
00081	0.016167	0.000773	29503	0.019486	0.000916
00082	0.030207	0.001633	29504	0.035625	0.001937
00083	0.019533	0.001074	29505	0.035580	0.001627
00084	0.008884	0.000431	29506	0.030043	0.001663
00085	0.019684	0.000951	29507	0.037472	0.001718
00086	0.033959	0.001864	29508	0.034051	0.001386

29509	0.023392	0.000847	29545	0.012562	0.000441
29510	0.018463	0.000864	29546	0.020039	0.001165
29511	0.037033	0.001975	29547	0.033828	0.001599
29512	0.028962	0.001290	29548	0.037396	0.002060
29513	0.021201	0.001194	29549	0.041488	0.002062
29514	0.030962	0.001355	29550	0.037336	0.001583
29515	0.029912	0.001167	29551	0.025233	0.000954
29516	0.021251	0.000739	29552	0.023961	0.000915
29517	0.016311	0.000771	29553	0.033843	0.001796
29518	0.035318	0.001873	29554	0.027390	0.001251
29519	0.022296	0.000968	29555	0.027429	0.001553
29520	0.016776	0.000772	29556	0.033715	0.001641
29521	0.024315	0.001014	29557	0.032618	0.001320
29522	0.026032	0.000962	29558	0.023084	0.000843
29523	0.019389	0.000625	29559	0.022352	0.000874
29524	0.013357	0.000658	29560	0.033817	0.001826
29525	0.031637	0.001689	29561	0.020931	0.000907
29526	0.016013	0.000706	29562	0.020936	0.001056
29527	0.016131	0.000549	29563	0.025927	0.001210
29528	0.020186	0.000769	29564	0.028080	0.001041
29529	0.021963	0.000803	29565	0.020672	0.000708
29530	0.017529	0.000527	29566	0.020292	0.000790
29531	0.011916	0.000563	29567	0.032292	0.001715
29532	0.027165	0.001488	29568	0.015037	0.000615
29533	0.010577	0.000550	29569	0.018323	0.000658
29534	0.016105	0.000653	29570	0.018543	0.000824
29535	0.019022	0.000719	29571	0.023087	0.000779
29536	0.020480	0.000741	29572	0.017935	0.000572
29537	0.015514	0.000461	29573	0.018143	0.000694
29538	0.012248	0.000492	29574	0.029131	0.001546
29539	0.022709	0.001309	29575	0.010003	0.000429
29540	0.009582	0.000505	29576	0.016106	0.000530
29541	0.015851	0.000872	29577	0.016393	0.000597
29542	0.017694	0.000830	29578	0.017944	0.000618
29543	0.019033	0.000787	29579	0.014919	0.000470
29544	0.013773	0.000452	29580	0.015995	0.000599

29581	0.025602	0.001374	29613	0.021467	0.000809
29582	0.006589	0.000364	29614	0.016077	0.000629
29583	0.015237	0.000671	29615	0.024359	0.000795
29584	0.015317	0.000628	29616	0.022984	0.001220
29585	0.014107	0.000645	29617	0.009445	0.000504
29586	0.012175	0.000464	29618	0.018163	0.000583
29587	0.013680	0.000502	29619	0.014362	0.000573
29588	0.022166	0.001216	29620	0.015557	0.000536
29589	0.007582	0.000353	29621	0.013266	0.000489
29590	0.015109	0.000842	29622	0.022086	0.000705
29591	0.013899	0.000775	29623	0.020944	0.001099
29592	0.014481	0.000788	29624	0.006974	0.000421
29593	0.010067	0.000574	29625	0.016423	0.000588
29594	0.011203	0.000424	29626	0.013565	0.000489
29595	0.019361	0.001094	29627	0.011762	0.000515
29596	0.026385	0.001350	29628	0.012933	0.000501
29597	0.034508	0.001897	29629	0.019564	0.000624
29598	0.037508	0.001898	29630	0.018640	0.000981
29599	0.033119	0.001497	29631	0.006572	0.000386
29600	0.022615	0.000951	29632	0.015613	0.000724
29601	0.028034	0.000910	29633	0.012384	0.000648
29602	0.025378	0.001255	29634	0.013058	0.000707
29603	0.020023	0.001001	29635	0.012760	0.000676
29604	0.023911	0.001357	29636	0.016690	0.000584
29605	0.027597	0.001419	29637	0.016731	0.000888
29606	0.027200	0.001159	29638	0.007273	0.000348
29607	0.019781	0.000806	29639	0.017357	0.000825
29608	0.026394	0.000869	29640	0.012792	0.000799
29609	0.023627	0.001296	29641	0.018016	0.000903
29610	0.014220	0.000701	29642	0.017916	0.000900
29611	0.020663	0.000878	29643	0.013600	0.000627
29612	0.017536	0.000945	29644	0.015884	0.000816

Over All Maximum L1 Error : 0.060023 (Sample 25969)

Over All Maximum L2 Error : 0.004701 (Sample 25969)

Appendix B The Training Data Set

Note: The Speed is in feet, Stern, rudder, and forward plane angle is in degree, and the Hold-time is in 1/10 of seconds.

Job:SUB11

Net:SUB11FIN

Speed	Stern	Rudder	Fwd	Hold-Time
5.0	15	0	-15	1000
5.0	-15	0	15	1000
5.0	15	0	-15	100
5.0	-15	15	15	100
5.0	-15	-15	15	100
5.0	15	3	15	100
5.0	-15	3	-15	800
2.0	-15	-15	15	1000
5.0	15	-15	-15	200
2.0	15	-15	-15	800
5.0	-15	-15	-12	350
5.0	-15	-15	15	350
5.0	-9	-15	-15	100
2.0	-15	15	9	1000
2.0	15	15	-15	1000
3.0	-15	-15	-12	1000
2.0	-3	3	15	1000
5.0	15	0	15	650
2.0	0	15	-15	100
3.0	12	0	3	1000
4.0	-9	15	15	200
3.0	-15	-15	9	200
2.0	-15	15	15	100
4.0	15	-15	15	200
5.0	0	-15	-15	200
3.0	-3	15	-9	1000
2.0	15	15	15	100
3.0	-6	-15	-15	100
5.0	-15	15	0	200
2.0	-6	9	-15	650
5.0	15	15	15	200
2.0	12	-15	15	100
2.0	-3	-15	-15	1000
3.0	-6	15	15	1000
2.0	-3	-15	-12	800
2.0	0	15	-12	1000
5.0	6	3	15	100
2.0	-15	12	-15	800
2.0	-9	-15	9	500
5.0	-15	-6	-12	100
4.0	9	-15	12	1000
4.0	-15	15	15	100
3.0	3	15	-9	1000
5.0	-12	9	-15	200
4.0	-6	15	12	100
2.0	-15	-6	15	100
5.0	15	15	-15	200
3.0	9	0	-15	1000
5.0	-15	15	-9	100
4.0	-15	0	15	200
2.0	15	3	-15	1000
2.0	-15	15	-15	500
4.0	-12	-15	-3	1000
3.0	9	-15	-12	1000
5.0	15	15	6	100
5.0	15	3	-15	200
4.0	12	15	3	1000
4.0	-12	15	9	1000
5.0	0	15	15	100
5.0	15	-15	-3	100
2.0	-6	15	0	800

5.0	15	6	15	200
4.0	6	0	-15	1000
2.0	15	15	-12	500
3.0	-3	15	15	800
2.0	6	3	-15	100
5.0	-15	0	12	100
2.0	15	15	15	350
3.0	-9	3	15	500
5.0	0	15	9	350
3.0	0	-15	15	350
4.0	15	-15	0	1000
5.0	12	0	-6	1000
2.0	-6	-6	-6	800
4.0	-15	6	-15	100
5.0	-15	-15	-15	200
5.0	3	-15	-15	650
3.0	-6	-15	-15	800
3.0	-9	15	-15	100
5.0	-15	0	3	100
4.0	-15	-6	9	650
2.0	0	15	15	100
4.0	15	15	-9	1000
5.0	15	-15	9	1000
2.0	-15	0	15	1000
2.0	-9	-3	15	100
5.0	3	15	15	1000
4.0	15	-3	15	1000
5.0	15	0	-15	800
3.0	-15	-12	-9	100
5.0	6	-15	6	100
3.0	15	-15	15	200
3.0	-15	15	-15	800
5.0	15	15	-6	800
4.0	0	-15	-15	100
2.0	-6	-12	-15	100
2.0	15	-15	6	100
4.0	3	-15	0	1000
5.0	15	0	0	1000
2.0	-12	12	12	200
5.0	6	-15	-15	1000
2.0	-3	0	15	100
2.0	3	-9	-15	1000
3.0	-15	15	15	350
5.0	-6	-3	15	200
5.0	-15	-12	15	200
3.0	0	15	15	800
5.0	-3	-15	15	500
4.0	-3	-15	12	100
2.0	-6	-9	15	1000
5.0	6	-15	-15	100
3.0	9	-12	9	1000
3.0	15	-15	-15	100
2.0	15	-15	3	800
2.0	15	-6	-15	100
2.0	-15	-15	-6	800
4.0	-15	12	9	100
2.0	-15	-15	-9	100
2.0	-15	-6	15	500
4.0	6	6	15	100
4.0	-12	3	9	650
5.0	0	-6	15	200
2.0	-3	-15	15	200
5.0	-6	-15	9	1000
5.0	-3	-3	-15	1000
3.0	-9	-12	15	1000
3.0	-9	15	15	500
2.0	15	15	-15	100
2.0	-15	6	0	1000
3.0	-15	15	-15	350
5.0	0	-15	15	200
4.0	-12	6	-6	100
3.0	-15	3	-6	100

3.0	-15	12	3	500
3.0	-15	15	15	1000
3.0	3	0	15	1000
4.0	6	-12	-15	650
4.0	9	-3	15	1000
5.0	-3	-15	9	100
5.0	15	-15	15	100
5.0	15	15	-15	100
5.0	15	-15	6	200
5.0	12	3	15	1000
3.0	-15	-9	-9	500
2.0	-6	0	6	1000
4.0	-15	-6	-15	1000
5.0	-15	0	-6	200
5.0	-15	-15	-15	1000
4.0	-6	-15	-12	500
5.0	3	15	-15	100
3.0	-6	15	15	350
2.0	-6	12	15	350
4.0	-15	-15	-9	100
5.0	-3	9	-9	100
3.0	-3	15	15	500
2.0	-6	12	15	500
4.0	-6	6	-15	100
4.0	-9	-6	3	1000
4.0	-6	15	-9	500
3.0	-3	-15	-6	500
3.0	-9	15	-15	500
4.0	3	-15	15	350
4.0	-9	15	15	500
4.0	-15	9	-15	350
4.0	9	12	-15	100
3.0	-12	6	15	100
4.0	15	15	-15	100
2.0	-9	15	-3	500
2.0	3	6	15	350

5.0	15	0	-15	650
3.0	12	9	3	100
5.0	-12	15	-15	200
5.0	-9	9	12	200
2.0	9	15	-15	350
4.0	15	0	-9	350
3.0	15	-9	15	100
5.0	-6	-6	15	100
5.0	-9	9	15	100
2.0	0	-15	15	650
5.0	9	-9	15	350
5.0	0	9	3	100
2.0	3	15	-15	350
3.0	6	-9	-15	1000
3.0	-15	-9	-15	350
5.0	9	9	-9	350
4.0	-15	15	-9	500
2.0	15	-3	3	1000
4.0	15	-15	15	650
2.0	-12	15	15	800
2.0	3	-15	15	350
4.0	-12	12	-15	100
3.0	-6	-15	15	100
4.0	6	15	-15	100
2.0	-15	0	15	800
3.0	-6	-15	-15	1000
3.0	15	-15	15	1000
2.0	15	-15	-9	200
5.0	15	15	9	1000
4.0	0	3	-12	1000
4.0	-9	9	-12	200
4.0	-15	-15	-15	500
3.0	-3	-6	-15	1000
3.0	-15	0	12	500
3.0	9	-15	15	100
3.0	-15	15	0	100

4.0	3	15	15	100	5.0	6	6	3	500
2.0	-15	-9	-15	200	3.0	3	3	-12	100
3.0	-12	-15	-15	500	5.0	-3	15	-15	100
2.0	9	-15	15	500	3.0	-6	-6	-15	200
4.0	15	-12	-15	500	2.0	-12	15	-15	650
5.0	-15	-15	15	1000	4.0	-6	15	-15	200
4.0	-3	15	-15	100	4.0	-6	-15	15	500
4.0	3	-12	15	500	3.0	9	-15	15	350
3.0	15	15	15	100	5.0	6	3	9	350
4.0	15	-3	-15	1000	5.0	-12	3	-15	100
2.0	-15	15	-15	100	5.0	0	9	-12	100
2.0	6	15	3	500	2.0	0	-9	0	650
5.0	0	-9	-15	350	4.0	3	15	15	800
5.0	-9	15	-12	1000	3.0	6	-6	-15	500
5.0	6	6	-12	1000	3.0	15	12	15	200
5.0	12	-12	-6	1000	4.0	-9	15	-15	500
4.0	-9	-9	-15	800	2.0	15	-6	15	1000
5.0	9	-9	-15	1000	2.0	9	15	6	1000
2.0	0	-15	15	1000	3.0	15	0	-15	1000
4.0	15	0	15	100	2.0	3	-12	-6	1000
3.0	-12	9	-6	100	3.0	0	15	15	100
2.0	-15	-15	15	200	2.0	-12	15	-15	1000
2.0	6	15	-9	1000	2.0	-3	15	15	100
3.0	-12	-15	15	800	4.0	9	-15	-12	200
3.0	-9	3	0	650	5.0	0	0	-15	1000
5.0	-12	-9	-6	650	2.0	6	-15	0	800
3.0	15	15	-12	200	5.0	-12	12	15	100
4.0	-12	-15	12	350	3.0	15	-6	12	1000
5.0	6	9	-6	800	5.0	15	3	15	350
2.0	-9	-15	-9	1000	4.0	9	-15	3	1000
4.0	6	0	-9	100	4.0	-6	0	9	100
5.0	6	-9	15	200	4.0	-3	3	-15	350
3.0	-9	-15	12	800	4.0	-12	15	-15	1000
4.0	6	-3	-15	350	5.0	12	6	-15	100
2.0	0	-3	-15	500	2.0	3	-3	3	350
3.0	-12	-15	15	500	4.0	-15	-6	15	100

4.0	-12	-15	-15	100
3.0	15	15	-15	100
2.0	-6	0	-12	500
3.0	-15	6	15	100
3.0	15	15	-9	1000
5.0	3	15	-15	200
5.0	15	0	3	350
5.0	15	-15	-15	350
5.0	15	-6	-15	1000
5.0	15	-12	-15	1000

Job:SUB12

Net:SUB12FIN

Speed	Stern	Rudder	Fwd	Hold-Time
5.0	-15	0	15	1000
5.0	15	0	-15	1000
5.0	-15	0	-15	1000
5.0	15	0	15	1000
5.0	15	15	-15	100
5.0	-15	9	15	100
5.0	15	-15	15	100
5.0	-15	-15	-15	100
2.0	15	15	15	650
5.0	-15	12	-12	800
5.0	15	-3	-15	650
2.0	-15	-15	15	1000
2.0	-3	15	15	100
5.0	-6	-15	15	650
5.0	3	-15	-15	500
5.0	3	15	-15	500
5.0	-15	15	-15	100
2.0	9	3	0	1000
5.0	15	15	-15	650
2.0	-15	3	-15	200
2.0	12	-15	15	200
2.0	9	15	-15	100
2.0	9	-12	-15	1000
2.0	-15	9	15	1000
3.0	-3	9	15	350
2.0	0	15	-15	1000
3.0	-6	3	-15	350
5.0	-15	-15	15	100
5.0	-15	-6	15	650
4.0	15	-15	15	1000
4.0	15	15	-15	500
2.0	15	15	-15	1000
5.0	3	-15	15	200
2.0	-9	-6	15	350
5.0	0	-15	-15	100
5.0	15	15	15	650
3.0	12	-15	15	650
3.0	-6	6	15	100
4.0	-9	15	-15	350
2.0	15	15	15	100
3.0	15	-3	-15	200
5.0	-12	6	-15	200
3.0	15	12	-15	800
2.0	15	-6	15	1000
4.0	-15	-15	15	350
5.0	12	9	15	350
2.0	6	-15	-15	100
2.0	-3	12	-15	350
3.0	12	15	15	200
3.0	-6	-15	15	100
2.0	15	12	-15	350
5.0	0	12	0	100
5.0	15	-15	12	500
5.0	-15	15	-12	200
3.0	-15	-15	-15	500
5.0	0	15	15	350
3.0	6	0	-15	800

2.0	-6	-15	-15	200
3.0	15	-3	-15	1000
4.0	3	-3	-15	800
5.0	15	-3	-15	200
5.0	12	15	15	800
2.0	-12	9	-15	800
3.0	-15	15	15	200
4.0	-15	12	15	650
5.0	-9	12	-15	500
2.0	-15	15	-15	100
2.0	15	-15	15	800
3.0	15	0	15	800
3.0	9	15	-9	1000
5.0	-6	15	15	1000
5.0	-15	-6	15	1000
2.0	6	3	-15	1000
2.0	12	-3	3	650
4.0	-6	3	-15	100
5.0	-15	15	12	200
3.0	15	-15	15	200
2.0	-15	-9	-15	1000
2.0	15	3	9	500
3.0	3	15	15	650
2.0	6	-15	15	1000
4.0	3	15	15	1000
2.0	-15	-15	15	100
5.0	-15	15	15	350
3.0	15	0	15	1000
2.0	6	0	15	100
4.0	3	-6	-15	1000
2.0	-3	-12	15	800
3.0	0	6	12	800
3.0	-9	-9	15	1000
2.0	-15	-15	-15	500
3.0	15	15	-15	500
2.0	-15	15	15	650

3.0	-15	-15	-15	100
3.0	-12	15	-15	1000
5.0	-9	9	6	650
5.0	-15	-15	15	350
2.0	3	-9	-15	800
3.0	-6	-15	-15	1000
2.0	-12	15	-15	1000
5.0	-15	15	15	800
2.0	12	9	-15	650
3.0	-15	0	15	800
5.0	15	-15	-9	800
5.0	6	6	15	650
5.0	15	15	15	500
4.0	6	-15	6	350
4.0	0	-15	-15	800
3.0	15	15	15	800
2.0	9	15	15	650
5.0	15	-15	-15	650
2.0	12	-6	-9	1000
2.0	12	0	-15	100
4.0	12	15	-3	1000
5.0	-15	-15	12	650
5.0	-15	0	-6	350
3.0	0	-12	15	1000
3.0	15	-15	3	1000
5.0	-15	6	15	500
4.0	-15	15	-12	200
2.0	-3	-15	-15	1000
5.0	3	3	15	800
4.0	9	-9	15	1000
5.0	3	15	-15	1000
5.0	0	-15	15	1000
5.0	-12	-15	-15	650
5.0	6	9	-15	200
5.0	15	0	15	100
4.0	-12	15	15	800

4.0	-15	-15	15	1000
5.0	15	0	-15	800
4.0	15	-9	-15	350
3.0	0	-6	15	350
3.0	-15	15	15	100
2.0	-6	-15	-15	500
4.0	15	-15	15	800
4.0	12	-12	-15	1000
2.0	-15	15	15	1000
3.0	-15	-3	-15	1000
5.0	0	3	-15	1000
5.0	15	9	-15	1000
5.0	15	3	-15	500
2.0	15	-9	-3	200
2.0	6	15	15	350
2.0	9	9	15	800
4.0	0	0	15	1000
5.0	-3	9	-15	800
4.0	6	-6	15	100
3.0	-6	-15	15	800
3.0	-15	6	15	1000
5.0	-9	6	0	1000
5.0	6	-15	-15	1000
5.0	9	-9	-3	800
2.0	15	-6	-15	500
5.0	6	-15	15	500
5.0	-15	-6	15	200
5.0	-3	-15	15	200
5.0	0	15	0	1000
5.0	-15	0	15	800
5.0	6	9	-15	1000
5.0	-9	-15	15	1000
3.0	-15	-15	15	800
5.0	15	-15	-15	200
5.0	15	-15	-15	350
2.0	-15	-6	15	800

2.0	-15	3	15	100
3.0	15	-3	-15	650
5.0	-9	0	15	500
2.0	-15	-15	15	650
2.0	-12	-9	-15	800
5.0	0	0	15	100
5.0	12	-6	15	200
5.0	-6	-9	-12	800
5.0	-15	15	-15	800
5.0	-6	12	15	800
5.0	15	15	-15	1000
5.0	15	9	-15	800
4.0	9	-15	0	800
5.0	15	-12	15	1000
2.0	-15	9	15	100
2.0	-9	3	-6	1000
5.0	-9	15	15	350
4.0	-15	-6	15	200
2.0	-9	-15	15	1000
5.0	9	-6	-15	100
2.0	0	15	15	1000
5.0	-6	0	-15	350
3.0	6	-3	15	1000
4.0	-6	3	15	1000
5.0	6	3	15	1000
5.0	6	15	-9	800
4.0	15	15	15	1000
4.0	15	3	-15	1000
5.0	6	-3	15	800
5.0	3	3	-15	800
4.0	15	0	15	350
5.0	12	-15	15	1000

Job:SUB13

Net:SUB13FIN

Speed	Stern	Rudder	Fwd	Hold-Time
5.0	15	15	15	1000
5.0	15	-15	15	1000
2.0	-15	15	-15	100
2.0	-15	-15	-15	100
5.0	15	9	15	1000
2.0	15	15	15	200
5.0	12	-6	-15	1000
2.0	15	-15	15	100
5.0	-3	-6	15	1000
5.0	15	15	-15	350
2.0	-15	12	15	650
2.0	15	-15	-15	200
5.0	15	6	-9	1000
5.0	6	-3	-15	100
5.0	-6	15	15	350
5.0	15	-6	15	500
2.0	-15	-15	-15	1000
2.0	-15	9	-15	1000
2.0	15	-15	15	1000
2.0	-15	0	-15	100
5.0	15	-3	-15	500
5.0	15	6	15	1000
2.0	-6	-3	15	800
2.0	-9	3	15	100
2.0	15	12	15	1000
5.0	-6	6	15	1000
5.0	-15	-9	-15	100
2.0	15	9	-15	100
3.0	15	-6	15	100
2.0	-15	-15	15	100
4.0	3	-3	9	1000
3.0	15	-3	15	100
3.0	3	-9	0	100
5.0	-15	-9	-15	1000
5.0	15	15	-6	100
3.0	-15	-3	15	200
3.0	-15	-12	12	350
5.0	15	-15	15	100
3.0	12	15	15	500
2.0	-15	-6	15	100
2.0	-15	-3	-12	650
5.0	15	9	15	200
2.0	15	12	15	100
3.0	6	-12	-15	800
5.0	-15	6	-15	1000
5.0	-15	3	15	100
3.0	-15	-3	-15	1000
2.0	3	-9	-15	100
5.0	15	-9	-12	200
5.0	3	3	15	1000
3.0	15	0	15	1000
5.0	-6	3	-15	100
2.0	9	3	15	500
2.0	-15	15	15	1000
4.0	-6	-15	15	500
2.0	15	-9	15	1000
2.0	15	6	-15	200
4.0	-9	9	-12	100
4.0	-3	-9	15	650
5.0	-15	-15	-15	100
2.0	15	15	-15	500
2.0	6	3	15	1000
3.0	12	-15	-15	100
2.0	-15	0	15	350
4.0	6	9	15	100
2.0	-15	6	-15	100
5.0	-15	-15	6	100
5.0	0	3	15	200

3.0	0	12	-15	100
5.0	-15	15	-15	100
5.0	12	3	-15	1000
5.0	-3	15	-15	650
2.0	15	15	15	800
2.0	-15	6	15	1000
5.0	-15	15	15	100
3.0	-15	9	-15	350
5.0	-6	3	-15	1000
2.0	-15	3	15	650
4.0	-15	6	15	100
5.0	15	0	15	100
3.0	15	12	-15	1000
2.0	-15	6	-15	650
2.0	15	-3	15	800
2.0	15	-15	15	500
5.0	15	0	15	650
2.0	15	-6	-15	500
5.0	-6	6	-15	650
5.0	9	3	-15	1000
5.0	3	-3	0	1000

Job:SUB14

Net:SUB14FIN

Speed	Stern	Rudder	Fwd	Hold-Time
5.0	15	15	15	650
5.0	15	-15	15	1000
5.0	15	12	-15	1000
5.0	3	15	-15	100
5.0	15	9	15	1000
5.0	-15	-15	15	100
5.0	-15	15	15	100
2.0	-15	15	-9	1000
2.0	-15	-15	-15	100
5.0	15	-9	-15	1000
2.0	15	-15	15	100
5.0	0	-9	15	1000
2.0	15	-15	15	1000
5.0	0	-15	15	500
5.0	15	-15	-15	500
2.0	15	15	15	100
5.0	-12	15	15	350
2.0	15	15	12	1000
2.0	15	-15	-15	1000
5.0	0	-6	15	650
5.0	9	15	15	500
5.0	15	3	15	100
2.0	-15	-15	15	1000
2.0	-15	9	-15	100
5.0	-3	15	-15	350
2.0	15	6	15	1000
2.0	15	0	15	100
5.0	-15	3	-15	500
4.0	-15	0	15	500
5.0	15	-15	15	100
5.0	-15	-15	-15	1000
5.0	15	9	15	100
5.0	15	6	15	1000
5.0	15	15	15	350
5.0	15	-9	15	1000
5.0	-15	-15	15	350
4.0	-15	15	15	200
4.0	-15	15	15	1000
4.0	15	-15	-15	350
3.0	15	15	-15	200
5.0	-15	15	-15	800
5.0	15	-15	-15	100
3.0	-15	-15	-15	500
3.0	-3	6	-15	1000
2.0	-15	15	-15	500
5.0	-15	-15	15	800

4.0	15	15	15	1000
2.0	9	-3	-15	100
3.0	-15	3	15	1000
4.0	-15	-15	-15	500
2.0	15	15	6	650
5.0	9	6	15	800
3.0	-15	3	-15	100
3.0	15	-9	15	200
2.0	15	-9	-15	500
2.0	-15	-15	12	200
2.0	-15	0	-9	1000
2.0	-15	0	15	500
4.0	-15	0	15	100
4.0	15	15	15	200
2.0	15	15	-3	350
4.0	15	15	-15	650
5.0	15	15	15	800
4.0	-15	15	-15	100
2.0	-15	0	15	100
4.0	-3	-9	15	100
5.0	3	3	15	1000
5.0	9	-15	15	350
5.0	15	-6	15	1000
3.0	15	15	12	1000
2.0	-15	-15	-15	500
3.0	-15	6	-15	650
5.0	15	-3	-12	350
4.0	-15	15	-15	650
2.0	15	3	15	500
2.0	-15	15	15	1000
5.0	-15	9	-15	200
5.0	15	-3	12	350
5.0	-15	12	15	1000
5.0	-15	15	-12	500
5.0	-15	-9	15	650
3.0	15	-15	15	500

4.0	-15	0	-3	100
5.0	-12	-15	-15	350
3.0	-15	-6	-6	1000
5.0	-15	15	-15	200
5.0	-15	15	-15	1000
4.0	15	15	15	350
5.0	6	9	-15	650
5.0	15	15	15	200
4.0	15	6	15	650
5.0	-3	-9	15	200
3.0	-15	12	-15	200
5.0	15	15	-12	1000
5.0	-15	15	-9	350
5.0	12	9	15	650
5.0	15	-15	-15	650
5.0	-15	-15	-15	200
3.0	-3	-15	15	350
5.0	15	3	-15	1000
2.0	15	15	-12	1000
5.0	9	15	-15	650
5.0	15	15	15	1000
2.0	-15	15	15	350
5.0	-15	-3	-15	100
2.0	15	0	15	1000
5.0	15	-6	12	100
5.0	-15	-6	-15	1000
5.0	12	-15	15	200
3.0	15	0	-15	1000
4.0	6	9	-6	800
4.0	15	-9	15	800
5.0	-15	3	-15	800
3.0	-15	-12	12	800
2.0	3	6	-15	500
5.0	-15	-15	15	500
5.0	-15	15	-15	650
3.0	-15	3	15	650

3.0	-15	3	15	100
2.0	15	12	-6	100
5.0	6	12	-15	800
5.0	12	-15	15	650
3.0	6	-6	15	1000
5.0	15	-3	-15	650
5.0	9	-6	15	800
5.0	-6	3	-15	1000
5.0	-15	9	-15	1000
5.0	-15	0	15	1000
4.0	3	6	-6	800
5.0	15	-3	-15	800

Job:SUB21

Net:SUB21FIN

Speed	Stern	Rudder	Fwd	Hold-Time
10.0	15	0	-15	1000
10.0	-15	0	15	1000
10.0	15	0	15	1000
10.0	-15	0	-15	1000
5.0	15	-3	-15	100
8.0	-15	15	15	100
5.0	-15	-15	15	100
10.0	15	0	15	100
5.0	15	15	15	1000
5.0	12	-15	-15	1000
5.0	-9	15	15	100
5.0	0	-15	15	100
10.0	3	15	-15	200
5.0	0	15	-15	100
8.0	3	-15	-9	500
9.0	15	-15	-15	200
5.0	-15	-15	15	1000
10.0	-15	-15	-15	100
8.0	0	6	-15	650
10.0	15	0	-15	500
8.0	0	-3	-15	350
9.0	15	6	15	200
10.0	-15	15	-15	100
9.0	-3	-3	15	350
6.0	-15	15	-15	1000
7.0	3	-9	-3	1000
5.0	-6	-15	-15	650
9.0	12	-15	-9	1000
10.0	-12	-15	15	100
8.0	-15	0	-9	200
5.0	15	0	15	1000
10.0	15	15	15	1000
8.0	-15	-15	-15	1000
10.0	3	0	15	1000
7.0	-15	-12	-15	100
10.0	-15	-3	-15	200
10.0	-12	15	15	100
5.0	-6	12	15	650
7.0	-9	15	15	1000
8.0	15	15	15	1000
10.0	9	-12	15	1000
8.0	15	0	15	1000
10.0	15	15	-15	1000
10.0	15	-3	-15	200
6.0	6	-15	9	500
10.0	-3	-15	15	100
9.0	15	15	-9	100
10.0	15	0	15	800
8.0	-15	-15	15	200
5.0	-6	-15	-15	1000
9.0	15	-15	15	650
9.0	-3	-15	15	1000
10.0	15	9	15	1000
10.0	12	-9	-15	800
8.0	-12	-9	-15	500

10.0	-12	-3	-15	100
5.0	3	-3	15	500
6.0	-3	-12	0	200
10.0	15	0	15	650
9.0	12	-6	15	1000
10.0	3	0	15	650
9.0	-12	15	-15	200
5.0	-9	-6	-15	1000
10.0	-15	-15	-15	200
10.0	-15	-9	15	100
5.0	12	-15	15	100
7.0	15	15	15	350
10.0	-6	15	-15	1000
10.0	0	0	-15	1000
10.0	9	-6	15	1000
6.0	-15	15	-15	100
10.0	0	-9	-15	1000
10.0	6	0	-15	100
7.0	15	-9	-15	100
5.0	-3	15	-15	800
10.0	6	15	15	100
7.0	-3	-15	15	1000
7.0	-6	-6	-15	1000
9.0	12	-3	15	100
10.0	6	-15	-15	100
5.0	15	-15	-15	500
10.0	-12	-15	15	350
10.0	6	15	15	1000
9.0	-3	-15	-15	1000
10.0	-3	6	15	200
10.0	15	-3	15	1000
10.0	15	0	15	350
10.0	-3	-6	-15	100
8.0	9	6	9	1000
5.0	6	15	-15	1000
10.0	-3	15	9	100

7.0	-9	9	-15	200
7.0	-15	-6	-3	1000
10.0	-15	-6	-6	500
9.0	12	3	-15	1000
10.0	15	0	-15	100
9.0	15	-15	15	100
10.0	0	-9	-3	200
7.0	15	0	15	200
9.0	15	6	-15	350
10.0	0	-3	15	1000
6.0	12	0	-15	350
10.0	15	-9	15	200
10.0	3	9	6	650
10.0	-15	15	15	500
10.0	-9	-9	15	200
5.0	15	-9	15	1000
5.0	12	-15	-15	100
7.0	-15	0	-9	100
10.0	9	15	6	650
10.0	0	-15	-6	350
10.0	6	-6	-15	1000
10.0	15	-3	-3	350
7.0	-12	-15	15	650
6.0	-6	-6	-15	500
5.0	0	-12	-15	1000
10.0	15	-15	15	800
10.0	0	-6	15	650
7.0	-6	-3	3	100
8.0	-9	-3	-15	650
10.0	9	-3	-15	1000
6.0	-12	-6	15	1000
5.0	-9	-6	-15	100
10.0	6	0	-3	1000
5.0	-12	-12	15	1000
9.0	9	-3	-15	1000
5.0	-15	15	-15	500

5.0	3	15	15	100
5.0	-15	-9	15	1000
10.0	15	-6	-15	1000
10.0	9	3	-15	1000
8.0	6	-6	-15	100
5.0	12	3	15	350
5.0	-15	-15	-15	1000
5.0	6	3	15	100
9.0	-3	-15	-15	100
7.0	-3	-9	15	650
5.0	-3	-6	15	100
6.0	9	6	-15	1000
6.0	12	15	-15	100
8.0	6	12	15	100
10.0	0	15	-15	1000
10.0	-15	-9	15	1000
7.0	15	-6	-15	100
5.0	15	15	-15	100
7.0	-15	-3	15	100
9.0	0	-15	15	100
10.0	-9	-15	-15	100
10.0	12	3	15	1000
10.0	-15	15	-15	500
10.0	-15	6	15	1000
10.0	15	15	6	100
10.0	15	-9	15	100
8.0	-15	-6	3	1000
7.0	-15	9	9	350
10.0	3	-12	-12	100
8.0	-9	-15	15	100
10.0	-6	15	15	350
10.0	6	-12	6	100
10.0	-3	-3	-15	500
9.0	6	15	-15	350
5.0	-15	0	15	100
10.0	15	0	-15	800
8.0	-9	3	15	1000
10.0	-12	-3	-15	650
5.0	-12	-9	-15	200
7.0	0	-15	15	100
10.0	12	-15	12	200
8.0	15	0	-15	1000
7.0	12	-3	15	1000
8.0	-15	-12	-15	350
10.0	-15	-6	9	1000
8.0	-15	-3	15	1000
5.0	-9	-9	0	200
5.0	-3	-6	-15	100

Job:SUB22

Net:SUB22

Speed	Stern	Rudder	Fwd	Hold-Time
10.0	-15	0	15	1000
10.0	15	0	-15	1000
10.0	-15	0	-15	1000
10.0	15	0	15	1000
10.0	15	9	-15	100
10.0	-15	3	15	100
5.0	-15	15	-15	100
7.0	15	-15	15	100
5.0	15	15	15	650
5.0	15	15	-3	800
5.0	-15	-15	15	100
10.0	9	-15	15	500
5.0	0	-15	-15	100
10.0	3	-15	-15	500
10.0	15	0	15	350
10.0	6	15	-15	500
5.0	9	0	15	200
10.0	-15	-15	-15	100
6.0	15	-15	15	650

5.0	-15	-15	15	1000	8.0	-12	0	-15	100
9.0	15	0	-15	350	5.0	15	-15	-15	100
5.0	15	15	-15	100	10.0	-3	-15	15	1000
5.0	-15	-9	-15	200	10.0	15	9	15	800
5.0	0	15	15	500	7.0	15	15	-15	350
6.0	15	-12	-15	200	5.0	-12	15	-15	500
10.0	15	6	15	100	10.0	-15	-15	-15	650
6.0	15	-15	-15	1000	10.0	-3	9	12	200
10.0	-15	15	-15	100	7.0	3	15	-15	1000
10.0	15	15	15	650	7.0	6	-6	-15	1000
10.0	6	-15	-15	200	6.0	-9	12	6	1000
10.0	-15	0	15	500	8.0	3	15	15	100
8.0	-9	15	-15	1000	5.0	0	15	15	1000
5.0	3	15	-15	200	7.0	9	6	15	1000
9.0	-15	-3	-15	200	10.0	15	-15	15	350
7.0	15	-15	-15	100	6.0	15	-3	15	500
9.0	15	15	-15	200	9.0	9	6	15	100
5.0	15	15	15	100	5.0	-12	6	-15	350
10.0	3	0	15	350	10.0	3	15	-15	1000
10.0	15	15	-15	800	5.0	-6	15	-15	1000
10.0	-15	0	15	800	9.0	-15	15	15	100
5.0	15	3	-15	200	6.0	9	3	-15	1000
10.0	-3	15	15	1000	8.0	12	-12	-15	1000
10.0	15	-12	15	800	10.0	12	-6	15	800
5.0	15	-15	-15	500	10.0	-15	6	15	800
5.0	15	0	15	1000	5.0	9	15	15	100
5.0	6	-15	15	1000	5.0	9	-15	-15	500
5.0	0	3	-15	650	5.0	-15	3	-15	500
5.0	0	15	3	100	7.0	-15	6	-15	100
6.0	15	3	-15	650	8.0	-3	-15	15	350
8.0	3	9	-15	1000	5.0	15	6	15	350
5.0	0	-15	-15	1000	5.0	15	-6	15	1000
10.0	15	-3	-15	100	5.0	-6	-9	15	1000
10.0	15	6	15	200	7.0	-6	6	-15	100
7.0	-15	-3	15	200	5.0	-3	15	15	100
10.0	15	-9	-15	800	10.0	-12	-6	15	500

5.0	0	15	-15	100	10.0	-15	9	15	650
5.0	-3	0	15	100	10.0	15	0	-15	650
10.0	9	0	15	100	7.0	-9	3	0	1000
8.0	3	-6	15	500	10.0	-15	-12	6	200
10.0	9	-15	-15	100	10.0	-6	6	0	100
7.0	15	-6	-6	100	10.0	-15	9	-15	200
10.0	-15	15	15	500	8.0	-12	15	-15	100
6.0	3	9	15	1000	10.0	-3	-12	-15	1000
5.0	-15	3	-15	1000	10.0	-9	15	-15	200
10.0	3	-6	-9	1000	5.0	-12	15	15	100
9.0	9	-6	15	200	5.0	-6	-3	-15	800
7.0	6	15	15	350	8.0	-15	-3	-15	100
10.0	6	12	-12	100	7.0	-3	3	3	650
7.0	-9	15	15	100	6.0	12	6	15	350
6.0	-15	12	-15	800	5.0	15	-3	-15	100
6.0	-6	6	9	350	5.0	3	0	15	1000
5.0	-3	-15	15	100	8.0	-6	-9	0	1000
5.0	12	12	-15	800	9.0	15	-12	-15	350
6.0	-12	12	15	200	9.0	12	-3	-15	800
10.0	0	0	15	650	5.0	9	-6	15	500
5.0	9	-9	15	100	5.0	15	-15	6	350
10.0	0	15	15	500	8.0	9	3	-15	200
7.0	-3	-9	-3	650	5.0	-9	-12	-15	100
10.0	9	6	-15	1000	7.0	9	15	15	100
5.0	-12	-15	3	350	8.0	15	-3	15	100
10.0	-15	-15	15	100	10.0	-6	12	-15	1000
5.0	9	6	15	100	10.0	15	0	-15	800
5.0	6	-9	15	800	10.0	6	-3	-15	500
8.0	15	15	15	100	5.0	-6	-12	15	650
10.0	6	12	15	100	6.0	-3	-12	-9	100
10.0	-3	-15	-15	100	6.0	9	-6	-15	800
5.0	-15	-9	15	500	8.0	6	-3	-15	1000
5.0	-15	-15	-15	100	8.0	3	0	-15	1000
5.0	-6	15	-15	100	10.0	3	0	15	800
5.0	15	-3	-15	650	5.0	-6	-3	15	800
7.0	-6	-3	15	1000	5.0	9	9	15	800

7.0	6	15	-15	350
8.0	15	-6	15	350
9.0	-3	15	-9	350
10.0	-3	-3	-15	500
7.0	12	-3	-12	800
5.0	12	15	-9	1000
7.0	15	-3	-15	1000
5.0	12	-15	15	1000
7.0	-15	-3	-3	350
10.0	12	-3	15	650
10.0	9	-15	15	100
7.0	15	-12	12	200
9.0	9	-6	15	1000
10.0	9	-15	15	1000
10.0	-15	-15	15	500
10.0	-15	15	-15	650
6.0	3	-15	-15	800
7.0	3	-15	15	100
6.0	-15	15	12	100
10.0	-3	15	-15	100
8.0	-12	-12	0	100
7.0	15	6	15	200
10.0	15	-15	15	100
7.0	15	3	-15	100
10.0	15	9	-9	500
9.0	15	0	15	500
10.0	-15	-6	-6	100
10.0	-9	-9	-15	200
5.0	-15	-6	15	100
5.0	0	15	-15	650
5.0	-12	12	15	500
8.0	-12	-6	-15	800
9.0	15	-6	12	500
7.0	15	-15	6	800
5.0	-15	-3	0	650
5.0	0	-6	-15	1000

10.0	15	15	15	100
10.0	15	6	15	1000
8.0	-9	-15	-15	350
9.0	-6	-3	12	200
10.0	-15	6	15	1000
5.0	-6	3	-15	1000
5.0	-15	-15	-15	1000
6.0	-15	9	-9	1000
5.0	-15	15	-15	800
8.0	12	6	-9	500
6.0	15	6	15	1000
6.0	9	0	9	1000
5.0	-3	3	-15	350
8.0	9	-6	-15	100
7.0	15	0	-15	350
10.0	6	9	15	650
10.0	0	15	15	100
5.0	15	-3	15	500
10.0	-3	-9	15	1000
5.0	-15	0	-6	200
8.0	0	3	15	500
10.0	-15	-6	15	1000
7.0	6	-3	15	100
5.0	12	-9	-15	350
10.0	15	-6	-15	100
10.0	15	0	-12	500
5.0	12	9	-15	1000
9.0	-9	-9	15	500
8.0	-15	-12	0	1000
5.0	-15	0	15	100
5.0	3	-3	15	350
5.0	3	-15	15	200
7.0	12	-12	15	350
10.0	12	6	-15	500
7.0	-15	-15	15	100
5.0	15	0	-15	800

5.0	3	-15	15	500
6.0	-12	-6	12	100
5.0	-6	-9	-15	100
6.0	9	-15	-15	1000
10.0	0	0	-15	1000
10.0	15	3	-15	800
6.0	3	6	15	100
5.0	15	9	15	200
6.0	3	-6	-9	100
5.0	15	-15	15	1000
6.0	-12	-9	-15	100
5.0	-15	-6	-15	100
10.0	-15	-3	15	200
8.0	-6	-3	15	1000
8.0	3	-3	-15	200
9.0	0	-15	15	100
5.0	3	-3	15	1000
5.0	-15	-6	-15	1000
10.0	-15	-9	15	1000
10.0	9	-6	-6	1000
5.0	12	-6	-12	1000
10.0	-12	15	-15	350
10.0	15	-12	-15	500
10.0	-6	-3	-3	350
7.0	-15	15	15	800
5.0	6	-6	-15	100
6.0	15	-3	-15	200
5.0	15	-9	15	100
6.0	-3	-15	15	800
8.0	12	0	15	1000
6.0	15	-3	15	200
9.0	0	12	3	650
10.0	9	15	9	1000
5.0	-9	-15	-3	800
6.0	15	-9	-15	800
10.0	3	0	-15	650

Job:sub23

Net:sub23

Speed	Stern	Rudder	Fwd	Hold-Time
10.0	15	15	15	1000
10.0	15	-15	15	1000
10.0	15	9	15	1000
10.0	15	-6	-15	1000
6.0	-15	15	-15	100
10.0	15	6	-15	1000
7.0	-15	-15	-15	100
10.0	-15	15	15	100
10.0	6	15	-15	100
5.0	-15	-15	15	100
5.0	-6	-3	15	1000
5.0	-15	3	-15	1000
10.0	15	3	15	1000
9.0	-15	15	15	350
10.0	-3	-3	15	500
5.0	15	6	15	100
10.0	-15	6	-15	200
10.0	15	-3	-15	800
5.0	-15	3	-15	100
10.0	15	-15	15	100
5.0	-15	-6	-15	200
5.0	-15	-15	-15	1000
7.0	15	-3	-15	350
10.0	15	-3	15	650
10.0	15	3	-15	1000
10.0	-3	3	15	1000
8.0	15	-3	15	1000
5.0	-15	15	-15	800
8.0	3	6	15	100
7.0	0	-12	-3	350
5.0	15	-6	-15	200

5.0	-15	-9	15	100
10.0	-12	-12	15	100
5.0	-15	-6	-15	500
5.0	12	-9	15	200
5.0	-15	9	9	100
7.0	9	-9	-15	100
6.0	15	3	-15	100
5.0	-15	-3	15	200
5.0	15	-15	15	1000
7.0	15	-9	15	100
10.0	-12	-9	-15	500
9.0	-15	9	-15	800
5.0	3	-12	-15	500
5.0	15	15	15	100
5.0	-6	6	-15	350
10.0	-15	-9	15	200
5.0	-15	-12	-15	800
5.0	-3	-12	15	500
5.0	15	9	15	800
9.0	-3	-12	15	100
10.0	-3	-12	15	350
10.0	-15	-15	15	100
5.0	-15	-12	15	200
8.0	-15	-3	15	100
5.0	15	-12	15	650
5.0	-15	-12	15	650
8.0	-12	-12	15	200
10.0	15	0	-12	100
8.0	-15	-12	-15	800
10.0	0	-3	15	1000
5.0	-15	9	15	650
5.0	-15	-12	-15	100
7.0	15	-9	15	350
9.0	-15	-15	15	500
5.0	-15	-9	-9	1000
5.0	-15	-12	15	350

5.0	-15	-6	15	100
5.0	6	15	-15	1000
6.0	-15	-9	-3	800
8.0	-15	15	-15	350
10.0	-15	-12	-15	200
8.0	6	15	-15	100
5.0	0	-15	-15	650
5.0	3	-9	0	800
5.0	15	-12	-15	200
6.0	0	3	15	1000
5.0	-15	-12	-9	500
6.0	-15	-9	3	650
6.0	-15	-9	-15	800
5.0	-15	-15	-15	650
6.0	-15	9	-15	1000
10.0	-12	6	-12	800
5.0	6	-9	-15	500
5.0	-15	-9	-15	650
5.0	0	0	-15	1000
5.0	15	9	15	500
8.0	15	15	15	200
5.0	-15	9	-15	100
6.0	15	0	15	100
5.0	-15	9	12	350
7.0	-12	15	-15	200
6.0	-15	15	-12	1000
7.0	-15	6	-15	100
10.0	0	15	15	200
5.0	15	-9	15	500
10.0	15	15	6	100
7.0	15	15	15	100
10.0	-15	12	15	1000
5.0	15	-3	15	350
7.0	15	9	15	650
8.0	-3	3	15	100
7.0	-15	15	15	100

9.0	-15	-6	-15	200
10.0	-15	6	15	500
8.0	0	0	-15	200
5.0	-15	15	-15	100
6.0	-15	12	-9	200
6.0	-15	-6	15	200
6.0	-15	3	-15	100
5.0	-15	-12	15	800
5.0	15	12	0	200
10.0	15	-6	-15	100
5.0	-15	15	-3	100
5.0	-6	12	12	100
5.0	15	15	15	500
5.0	-6	-12	0	650
5.0	0	9	-9	100
6.0	15	-6	-3	350
10.0	15	15	15	200
9.0	-15	-9	15	100
5.0	-15	-15	9	650
10.0	0	9	-15	100
5.0	15	15	-15	350
10.0	-15	15	-15	200
8.0	-15	12	-3	500
8.0	3	3	-15	500
5.0	15	-9	15	800
5.0	15	-6	15	100
5.0	15	-3	-15	100
10.0	-12	9	15	100
9.0	-6	15	-15	100
10.0	-15	12	-15	350
8.0	-15	3	-15	350
5.0	-9	3	15	100
6.0	-6	-9	-15	650
5.0	15	0	15	100
5.0	15	12	-15	800
7.0	-15	6	6	1000
8.0	-15	-6	15	800
9.0	-15	9	15	350
6.0	15	3	-6	800
7.0	0	15	15	1000
5.0	3	-12	-9	800
8.0	-15	6	15	100
5.0	-15	3	-15	650
6.0	-15	-3	-12	1000
8.0	-15	-6	-15	100
5.0	-15	-15	-6	650
8.0	-15	15	15	1000
8.0	12	-3	15	100
6.0	0	3	15	800
5.0	-15	3	0	650
10.0	-15	15	-3	200
5.0	-9	-15	15	500
5.0	-12	0	-9	500
5.0	-15	9	-15	650
9.0	-15	15	-15	650
5.0	-15	12	15	1000
6.0	15	12	-15	100
10.0	15	-15	15	500
10.0	-15	-9	-15	100
7.0	-6	15	-15	100
10.0	12	12	-15	100
10.0	15	9	6	100
5.0	-15	-3	-15	1000
6.0	0	3	6	500
5.0	15	3	-12	100
5.0	15	9	3	100
6.0	15	-15	-15	650
10.0	-15	15	6	500
5.0	0	-9	-3	100
7.0	0	15	-9	350
5.0	9	15	-6	650
5.0	15	12	15	200

10.0	-15	-3	-15	1000
5.0	15	15	-9	100
5.0	-15	-3	-15	650
8.0	-12	15	-12	1000
5.0	-15	15	15	350
9.0	15	12	-15	350
10.0	6	15	6	100
5.0	-15	-12	15	1000
10.0	-9	12	-15	100
6.0	-12	12	-15	350
6.0	-6	-6	-15	1000
5.0	0	9	15	100
10.0	15	-3	0	1000
8.0	-3	3	15	1000
7.0	9	6	12	100
7.0	-15	0	6	100
6.0	15	9	-15	650
10.0	-12	0	-15	100
5.0	15	-6	15	1000
10.0	-3	15	-15	350
6.0	-9	-3	-15	650
6.0	-12	15	15	650
8.0	-15	-6	-6	1000
5.0	-3	-3	9	800
5.0	15	-12	15	100
5.0	15	-12	-15	100
6.0	0	15	15	350
5.0	-15	15	15	100
5.0	-6	12	-15	200
5.0	-15	-6	12	650
7.0	-12	-15	9	800
10.0	9	-15	-15	100
10.0	-6	12	0	100
10.0	-15	15	15	1000
5.0	-9	9	15	650
5.0	15	12	15	100

8.0	-15	-12	15	1000
8.0	-9	-15	15	1000
8.0	-15	-12	-15	1000
5.0	-15	15	-15	200
5.0	15	-6	-15	800
10.0	-6	-9	15	100
10.0	-3	-15	15	1000
10.0	-15	-12	15	1000
5.0	-6	12	-15	100
5.0	-15	15	-15	500
6.0	6	3	-15	800
7.0	9	6	15	650
10.0	-15	12	-15	100
10.0	15	9	15	350
7.0	15	15	-3	500
7.0	-3	3	-15	200
7.0	3	-15	15	100
5.0	15	-15	6	100
5.0	6	3	-15	100
10.0	-15	3	-15	1000
5.0	-15	0	-9	800
8.0	15	15	-9	100
10.0	-15	0	12	650
10.0	12	-9	15	100
7.0	9	6	-12	100
5.0	-9	0	-15	650
10.0	15	-12	-15	100
8.0	0	-15	-15	200
6.0	-9	15	12	200
10.0	-9	0	15	100
7.0	6	9	-6	100
9.0	-15	-15	-15	500
5.0	15	-3	-15	1000
8.0	-15	9	-15	100
10.0	0	-9	-6	100
10.0	0	-3	15	100

6.0	12	6	15	800
7.0	15	9	15	100
8.0	0	9	-15	800
7.0	-6	15	15	200
6.0	6	15	15	800
5.0	-6	9	15	100
10.0	-15	0	-12	350
6.0	0	-3	-15	100
8.0	-3	-15	-15	650
6.0	3	15	-15	100
10.0	-9	9	-3	350
8.0	-15	-3	-15	1000
7.0	-15	12	15	200
5.0	-15	9	15	1000
10.0	-3	3	15	500
10.0	15	0	15	100
5.0	-15	12	-12	100
5.0	15	15	-15	200
9.0	15	3	6	100
5.0	3	15	-15	100
10.0	-9	6	-9	100
7.0	0	0	15	650
10.0	9	9	-15	350
5.0	-15	6	-15	100
6.0	0	12	0	100
10.0	15	12	-6	100
5.0	-15	6	-9	500
9.0	-15	15	-15	100
5.0	-6	6	-15	100
5.0	12	9	-15	350
10.0	-3	12	-15	350
7.0	-15	3	-6	500
10.0	3	-6	-15	100
8.0	15	-15	-12	500
5.0	15	3	-15	350
5.0	15	9	-15	1000

10.0	15	6	9	350
10.0	15	6	-15	350
5.0	15	3	15	1000
6.0	-6	-15	-15	650
8.0	0	15	15	800
6.0	12	9	-12	200
7.0	-15	-3	-15	500
7.0	-15	-6	-9	800
6.0	-15	6	15	800
6.0	-15	9	-6	100
5.0	12	9	-15	100
5.0	15	12	15	650
7.0	15	3	15	350
9.0	-15	-12	-15	1000
5.0	3	-12	15	100
9.0	-12	-12	-15	100
5.0	12	6	15	350
10.0	-15	-9	-15	1000
9.0	-15	-12	9	650
10.0	12	0	15	350
10.0	-15	-15	-12	500
5.0	-15	-3	-12	100
5.0	-15	-6	15	1000
10.0	-15	-15	-9	100
5.0	-15	-15	-15	200
6.0	-12	-6	-15	200
5.0	0	3	12	800
5.0	-6	-6	15	800
7.0	-15	-9	12	800
5.0	-15	15	3	200
6.0	-15	9	-9	500
9.0	-9	9	15	200
5.0	-9	6	15	100
10.0	-15	-6	-15	800
6.0	15	15	6	100
10.0	9	6	-15	100

5.0	0	6	15	650
7.0	9	12	15	100
7.0	15	3	15	100
5.0	-6	-6	-9	650
9.0	0	6	15	350
5.0	3	9	6	800
5.0	-15	6	-15	1000
6.0	-12	3	0	1000
5.0	9	0	-15	350
8.0	0	15	15	100
7.0	15	3	-15	1000
10.0	-6	3	-15	1000
9.0	-6	-6	-15	350
9.0	-15	-3	-15	800
5.0	0	15	12	100
10.0	-15	-3	0	1000
7.0	9	0	15	800
5.0	-3	12	-15	800
6.0	15	15	-15	200
8.0	-15	3	15	650
8.0	-12	6	-15	1000
8.0	-12	9	15	100
6.0	0	6	-15	500
5.0	15	15	12	1000
7.0	15	-6	15	1000
10.0	-12	3	15	350
8.0	-15	15	15	200
10.0	3	12	15	200
7.0	-3	-12	-15	100
7.0	15	15	-15	350
9.0	15	12	-15	650
7.0	-15	-3	-15	200
10.0	-15	-9	15	800
8.0	15	9	15	350
6.0	3	12	15	200
10.0	-3	-3	15	800

6.0	0	15	15	100
9.0	-15	12	15	100
9.0	15	15	15	100
5.0	-12	-12	-15	650
10.0	-15	-6	-15	650
9.0	-15	0	15	800
5.0	-15	6	15	1000
5.0	12	3	-15	1000
8.0	-12	12	-15	100
7.0	-15	12	-15	350
6.0	-15	0	9	1000
9.0	-15	3	9	1000
10.0	-9	-3	-9	650
7.0	3	0	15	200
10.0	-12	-6	3	100
10.0	-15	-3	15	500
6.0	6	-6	-15	100
9.0	-12	-9	-15	800
10.0	15	-9	-12	800
9.0	6	3	-15	800
5.0	6	-6	-9	800
10.0	-9	0	-15	800
8.0	0	3	-15	350
5.0	-9	9	-15	1000
9.0	-15	3	15	100
10.0	-15	3	15	800
8.0	-3	3	-3	350
10.0	0	3	15	1000
10.0	-3	3	-15	800
6.0	-15	15	-15	500
9.0	-3	9	-15	200
9.0	-15	-6	-12	800
8.0	6	12	15	200
7.0	-6	3	15	1000
7.0	9	15	15	200
5.0	-15	-6	-15	1000

7.0	12	15	-15	100
10.0	0	-12	-15	100
8.0	-6	-15	15	200
10.0	15	3	15	800
8.0	-15	-12	15	100
9.0	-6	-6	6	800
8.0	-6	3	6	800
8.0	-12	-6	-15	800
5.0	12	-6	-15	1000
5.0	15	9	15	1000
8.0	-6	0	15	800
9.0	-6	-6	-15	1000
9.0	-15	-15	-15	200
7.0	-15	6	-15	800
5.0	-6	-9	15	1000
9.0	15	3	15	1000

Job:sub24

Net:sub24

Speed	Stern	Rudder	Fwd	Hold-Time
10.0	15	15	-15	1000
10.0	15	-15	15	1000
10.0	15	15	15	350
10.0	15	-12	-15	350
10.0	15	9	15	500
10.0	15	-9	-15	500
5.0	-15	15	-15	100
10.0	15	3	15	800
5.0	-15	-15	15	100
10.0	15	-6	15	1000
10.0	15	6	-15	1000
5.0	-15	-15	-15	100
5.0	-15	15	15	100
5.0	15	15	15	100
10.0	15	3	15	1000
10.0	15	-3	-15	800
10.0	-15	-9	15	1000
5.0	-15	9	15	1000
10.0	15	3	-15	1000
10.0	15	-6	15	500
10.0	-15	-15	15	100
10.0	-15	-3	-15	200
10.0	-12	15	-15	350
5.0	15	-3	-15	100
5.0	15	9	15	1000
5.0	-15	-3	-15	500
5.0	15	-15	15	1000
10.0	15	-15	15	100
7.0	15	-3	-15	800
10.0	15	-15	-15	1000
10.0	-15	-15	15	650
5.0	15	15	-15	1000
9.0	15	6	-15	500
9.0	15	-3	0	1000
10.0	15	15	15	100
7.0	6	15	9	500
6.0	-9	-12	-15	1000
8.0	-15	-15	-6	350
10.0	15	3	15	350
6.0	15	9	-15	1000
8.0	-15	15	12	1000
10.0	-12	9	-15	650
7.0	6	-15	15	100
5.0	6	15	15	350
10.0	15	-3	12	1000
7.0	15	15	-15	100
5.0	-15	3	-15	100
5.0	-15	15	6	1000
9.0	-15	-12	-15	100
7.0	15	-15	-15	500
10.0	15	-9	-3	100

5.0	-3	-9	-15	350
10.0	15	-15	15	350
5.0	15	12	-15	350
9.0	15	-15	-15	200
8.0	-15	-12	15	800
10.0	-15	6	-15	500
8.0	15	-9	-15	100
8.0	-15	-15	-15	200
5.0	-15	-15	15	500
9.0	3	9	0	200
10.0	15	6	15	100
8.0	-15	3	15	1000
10.0	-15	0	15	100
7.0	-15	9	-15	800
10.0	-15	-12	-6	100
10.0	-15	15	-15	1000
5.0	-15	0	6	100
5.0	15	-12	-15	100
7.0	-15	-3	15	800
10.0	-15	3	15	1000
10.0	15	12	15	1000
8.0	-15	12	-15	100
8.0	3	-3	-15	350
7.0	-15	6	-3	100
9.0	-15	0	15	650
10.0	-15	-9	15	350
10.0	-15	-15	15	800
10.0	3	6	15	200
9.0	15	15	15	100
5.0	15	12	9	800
9.0	-15	15	-15	800
7.0	3	-6	15	500
5.0	15	-6	15	100
5.0	-15	-12	-15	200
10.0	-15	12	-12	1000
10.0	15	-9	-15	1000

6.0	-15	15	0	100
10.0	-15	-12	-15	800
10.0	-15	15	6	100
10.0	15	15	15	200
7.0	-9	-15	0	100
10.0	3	-15	15	200
9.0	-12	9	-15	800
10.0	-15	-3	-15	650
10.0	15	-12	-15	650
10.0	-15	12	-12	200
5.0	-15	0	12	1000
6.0	15	-9	-15	1000
8.0	15	12	-15	100
8.0	15	-15	-15	100
10.0	15	15	-15	350
10.0	15	0	-15	100
9.0	15	-9	15	100
5.0	15	-15	-3	350
9.0	0	3	15	800
10.0	15	12	-15	500
10.0	15	-3	-15	650
8.0	-15	15	-15	350
10.0	3	3	15	650
7.0	-15	-9	-15	100
5.0	3	-3	-9	1000
10.0	-6	-6	-15	1000
10.0	-15	9	15	100
5.0	15	-6	-12	500
9.0	15	6	-3	100
8.0	9	0	-15	100
5.0	-15	-9	-15	1000
5.0	15	9	-15	100
7.0	15	-12	-15	650
9.0	6	12	-15	650
9.0	-15	0	-15	800
10.0	-15	9	-9	350

5.0	-15	-9	-15	100
5.0	-9	-12	-15	500
7.0	15	3	15	800
5.0	-6	-6	6	500
6.0	15	-9	15	200
10.0	15	9	-6	800
7.0	0	15	3	200
5.0	-15	9	-15	350
6.0	-6	3	-15	350
6.0	-15	-6	-15	800
10.0	-9	0	-15	350
8.0	15	12	12	500
9.0	-15	-6	15	800
6.0	-15	12	-9	500
10.0	-9	-9	15	200
5.0	-15	-3	-15	100
5.0	0	-9	6	1000
5.0	15	-3	15	650
5.0	-15	0	-15	1000
10.0	12	3	-15	650
7.0	15	-15	9	650
5.0	-15	-9	-3	650
10.0	15	-6	-15	500
6.0	6	15	6	1000
6.0	15	9	-3	350
10.0	15	12	-15	200
10.0	-15	-15	15	500
5.0	-15	-9	15	100
5.0	15	-15	15	350
10.0	15	6	15	650
10.0	-15	15	15	1000
10.0	-3	9	-15	100
5.0	3	6	-15	100
10.0	-15	15	15	350
7.0	3	15	12	650
6.0	15	-6	-3	650

5.0	15	3	9	1000
5.0	12	-6	-15	1000
10.0	-15	0	15	1000
5.0	-15	6	15	100
10.0	-15	-15	15	350
10.0	-15	12	-15	650
10.0	-12	3	-15	350
5.0	15	15	15	1000
10.0	-15	12	-15	500
10.0	15	6	15	500
10.0	-15	6	-15	800
6.0	-15	6	0	1000
5.0	-3	-9	15	800
5.0	15	0	9	200
9.0	6	0	15	100
5.0	15	-9	6	800
10.0	-15	0	15	200
10.0	-6	15	15	650
5.0	-15	9	6	100
9.0	-12	3	15	200
9.0	15	3	3	200
10.0	-15	3	-12	100
5.0	15	15	9	350
7.0	15	6	-15	800
5.0	-15	15	-15	1000
10.0	15	0	6	350
10.0	15	6	15	800
9.0	-15	-12	-15	1000
7.0	9	0	0	100
5.0	-15	9	15	800
10.0	15	0	-6	350
10.0	-6	6	-15	650
5.0	0	-3	15	200
10.0	-15	3	12	200
10.0	-15	9	12	1000
8.0	15	-3	-15	1000

10.0	15	12	15	650
7.0	-15	-15	-15	1000
10.0	-15	9	15	800
6.0	15	6	15	200
10.0	-15	6	15	100
10.0	-15	-12	15	1000
8.0	-15	3	15	100
10.0	-15	15	3	800
10.0	15	3	-15	500
10.0	-3	-9	15	500
9.0	-15	-6	15	100
5.0	-9	0	15	650
9.0	15	-6	15	350
10.0	-6	3	-15	650
10.0	0	-6	15	500
10.0	15	3	3	1000
10.0	-15	-6	15	1000
10.0	-6	-9	15	800
10.0	-12	6	-15	1000
6.0	-15	6	3	500
10.0	15	-3	-15	1000
10.0	6	-6	15	200
10.0	15	-15	-15	200
10.0	-15	-15	-15	350
10.0	15	-12	-15	800
10.0	15	15	-15	100
10.0	15	3	-15	800
10.0	15	-9	15	800
10.0	15	-6	-15	1000
10.0	-15	-3	0	1000
7.0	3	-9	15	1000
10.0	-3	-3	15	800
10.0	-12	-6	15	800
8.0	15	-9	15	650
10.0	15	-6	12	800
10.0	-15	-9	-3	1000
10.0	-6	-15	15	650
10.0	12	-12	-15	100
8.0	-3	-6	15	1000
10.0	15	-6	-15	650
10.0	3	-15	-12	200
10.0	-9	-6	15	650
10.0	-9	12	-15	200
10.0	6	9	15	350
8.0	15	-3	15	800
10.0	-3	0	-15	800
10.0	15	-3	9	100
10.0	-15	-6	-15	1000
10.0	-15	15	-15	100
10.0	-15	-15	15	200
10.0	-6	-12	15	350
10.0	3	15	-15	200
10.0	-6	-15	-15	650
10.0	15	-12	15	500
10.0	-9	-12	-3	1000
9.0	15	-3	15	650
10.0	12	0	15	800
10.0	-3	15	15	100
10.0	9	-6	15	650

Job:SUB31

Net:SUB31

Speed	Stern	Rudder	Fwd	Hold-Time
15.0	15	0	-15	1000.0
15.0	-15	0	15	1000.0
15.0	15	0	15	1000.0
15.0	-15	0	-15	1000.0
10.0	15	0	-15	100.0
10.0	-15	15	15	100.0
10.0	-15	-15	-15	100.0

13.0	15	0	15	100.0
10.0	15	15	15	1000.0
15.0	-15	15	15	100.0
10.0	3	-15	15	100.0
15.0	3	15	-15	200.0
15.0	6	-15	15	200.0
15.0	15	0	-15	350.0
11.0	0	15	-5	1000.0
15.0	-15	-15	15	100.0
10.0	-3	15	15	100.0
11.0	15	-15	-15	1000.0
15.0	15	-9	15	100.0
10.0	-15	-15	-15	1000.0
15.0	-3	0	-15	500.0
13.0	15	0	-15	1000.0
15.0	12	-15	-15	650.0
15.0	12	15	15	1000.0
15.0	15	0	0	650.0
15.0	15	-15	15	1000.0
15.0	3	0	5	1000.0
11.0	-9	-3	15	500.0
11.0	15	0	15	350.0
15.0	3	-6	15	800.0
15.0	15	15	15	650.0
11.0	15	0	-15	1000.0
13.0	6	-9	-15	1000.0
15.0	-6	15	15	1000.0
15.0	15	15	-15	800.0
12.0	15	0	15	1000.0
13.0	12	-6	-5	1000.0
12.0	9	6	10	1000.0
10.0	15	-15	-15	350.0
15.0	3	-15	15	1000.0
15.0	-3	-15	15	1000.0
15.0	6	9	15	1000.0
11.0	6	-9	10	1000.0
10.0	-15	15	15	1000.0
12.0	-15	15	-15	1000.0
10.0	-6	9	-15	650.0
15.0	3	15	15	800.0
10.0	6	-15	-5	800.0
10.0	-3	-6	10	200.0
15.0	6	-6	-15	1000.0
15.0	3	0	15	800.0
15.0	15	9	0	1000.0
10.0	-12	-9	-15	650.0
11.0	-15	-6	15	100.0
15.0	-15	12	15	200.0
15.0	-15	-6	-15	100.0
11.0	-6	15	-15	100.0
10.0	15	15	-15	100.0
15.0	6	-6	-15	500.0
15.0	15	0	-15	200.0
10.0	9	-9	15	100.0
15.0	15	-15	15	200.0
15.0	15	-3	-15	100.0
10.0	12	-6	-15	1000.0
13.0	-15	-15	15	1000.0
15.0	15	6	-15	100.0
15.0	0	15	-15	1000.0
15.0	0	0	-15	1000.0
10.0	15	-9	15	500.0
12.0	-15	15	-15	100.0
10.0	3	0	0	1000.0
13.0	9	-3	-15	1000.0
13.0	-6	-9	15	500.0
15.0	15	15	-15	200.0
12.0	3	9	-10	350.0
13.0	6	0	-15	800.0
15.0	-15	15	15	500.0
12.0	15	0	-15	350.0
15.0	0	9	5	100.0

15.0	-6	15	-10	350.0
12.0	6	-9	0	350.0
10.0	12	3	-5	350.0
12.0	-15	-15	15	100.0
15.0	15	-6	-15	200.0
13.0	9	3	-15	1000.0
12.0	15	-15	10	650.0
11.0	9	-6	15	200.0
12.0	-3	15	15	200.0
15.0	15	-3	15	1000.0
10.0	3	15	5	100.0
10.0	15	-9	15	100.0
12.0	15	-15	-15	100.0
10.0	-9	-15	15	200.0
15.0	15	-6	-15	1000.0
11.0	6	-3	-15	500.0
10.0	6	-3	0	100.0
15.0	15	0	15	650.0
15.0	6	0	10	100.0
12.0	0	-12	15	1000.0
15.0	-15	-6	15	350.0
15.0	9	-9	-15	100.0
13.0	-15	-9	0	350.0
10.0	12	-9	15	1000.0
13.0	-12	-15	-15	100.0
10.0	3	-12	-10	350.0
12.0	6	-15	15	100.0
15.0	0	0	0	100.0
15.0	15	0	15	200.0
15.0	12	3	15	1000.0
10.0	0	3	15	100.0
13.0	-15	-3	15	350.0
11.0	15	-3	0	200.0
11.0	15	6	-5	500.0
10.0	3	15	0	350.0
15.0	-3	-9	-15	650.0

15.0	-15	15	-15	100.0
15.0	-9	12	-15	350.0
11.0	15	12	5	100.0
10.0	-15	0	-15	100.0
13.0	15	-3	-10	1000.0
12.0	3	-3	-15	100.0
10.0	-15	6	-15	800.0
13.0	15	-6	-5	100.0
13.0	15	9	15	1000.0
15.0	15	15	15	100.0
12.0	-15	-6	-15	1000.0
11.0	-15	-9	5	800.0
10.0	-9	-15	15	800.0
10.0	15	6	10	1000.0
10.0	15	15	-15	650.0
10.0	6	15	15	1000.0
10.0	15	15	15	200.0
10.0	-15	-15	-15	650.0
15.0	6	6	15	1000.0
10.0	15	0	-15	800.0
12.0	-9	-15	15	350.0
10.0	6	6	15	1000.0
15.0	12	-3	10	1000.0
15.0	12	-3	-15	1000.0
12.0	-15	0	-15	1000.0
15.0	12	3	-15	800.0
15.0	9	3	-15	1000.0
15.0	15	3	-10	1000.0
15.0	12	0	15	1000.0
15.0	-12	-9	-15	200.0
11.0	-15	-12	15	100.0
10.0	-9	6	15	100.0
10.0	-15	6	15	350.0
10.0	-12	-6	15	1000.0
12.0	-12	15	15	1000.0
13.0	9	-3	-15	650.0

15.0	3	3	15	650.0
10.0	3	-15	-15	1000.0
15.0	9	-15	-15	1000.0
10.0	-12	15	15	650.0
10.0	-15	0	-15	1000.0
10.0	-12	-9	15	350.0
11.0	6	-6	15	1000.0
13.0	-12	-15	-5	350.0
15.0	12	-3	-15	650.0
10.0	-3	-3	-15	100.0
12.0	-3	0	-15	200.0
12.0	-6	-12	15	100.0
12.0	9	-12	-10	100.0
15.0	9	-3	15	100.0
15.0	15	-6	-15	650.0
15.0	-6	-6	15	100.0
15.0	-3	-9	-15	200.0
10.0	-6	0	0	350.0
11.0	12	15	15	200.0
10.0	15	-3	15	100.0
15.0	-6	-9	15	100.0
15.0	-3	-6	-15	100.0
10.0	-15	-3	10	1000.0
15.0	-9	15	15	200.0
15.0	6	0	15	1000.0
12.0	15	15	15	500.0
10.0	-6	6	-15	1000.0
13.0	12	0	15	800.0
10.0	-15	-9	15	200.0
10.0	-6	-9	-15	350.0
15.0	9	-3	5	650.0
13.0	-3	15	15	1000.0
13.0	15	-9	-15	100.0
10.0	9	15	15	100.0
15.0	0	-3	-10	350.0
15.0	9	0	0	800.0

13.0	9	-3	15	500.0
10.0	-6	12	15	500.0
11.0	-6	12	10	1000.0
15.0	3	0	15	350.0
11.0	-15	12	15	800.0
15.0	-3	-15	-15	500.0
11.0	0	-15	15	500.0
13.0	15	-9	15	350.0
15.0	-6	-15	0	100.0
10.0	-6	9	10	1000.0
11.0	-9	15	-15	800.0
13.0	3	0	15	350.0
15.0	9	-6	15	100.0
10.0	-15	-9	-15	500.0
10.0	-15	-15	15	350.0
12.0	12	0	10	800.0
12.0	3	-6	0	1000.0
10.0	9	15	-15	100.0
15.0	12	-6	10	1000.0
15.0	-15	-9	-15	1000.0
10.0	15	-3	15	1000.0
15.0	6	15	15	100.0
10.0	-9	-15	-15	100.0
15.0	-15	-9	15	200.0
11.0	12	0	5	1000.0
10.0	12	-12	15	100.0
15.0	15	-6	15	200.0
10.0	-15	15	15	650.0
10.0	9	-9	-15	350.0
11.0	12	-6	15	500.0
15.0	-15	9	15	100.0
10.0	15	15	15	500.0
12.0	0	3	0	1000.0
10.0	-9	-6	-15	650.0
13.0	0	15	10	100.0
13.0	-15	-12	-15	650.0

15.0	6	15	0	100.0
10.0	9	-3	15	800.0
12.0	15	15	15	200.0
15.0	-6	3	-10	100.0
13.0	15	-3	5	1000.0
10.0	-15	-9	-15	100.0
11.0	-15	6	-15	200.0
11.0	12	-15	15	100.0
10.0	-15	-15	15	100.0
13.0	3	15	0	1000.0
15.0	6	-9	15	1000.0
15.0	-3	-6	15	650.0
15.0	3	-3	5	1000.0
15.0	6	-3	15	200.0
10.0	0	-15	0	200.0
10.0	-9	-9	15	800.0
15.0	0	-12	-15	200.0
15.0	12	-9	-5	100.0
15.0	15	0	15	100.0
13.0	9	15	10	100.0
15.0	-3	-3	15	100.0
15.0	12	15	15	350.0
10.0	-6	15	15	350.0
13.0	-6	-3	15	200.0
10.0	0	-6	0	800.0
10.0	-3	0	-15	200.0
12.0	6	3	-10	100.0
13.0	0	0	15	1000.0
11.0	15	-15	15	350.0
10.0	15	-6	-5	500.0
11.0	-3	0	15	100.0
15.0	-12	15	-15	500.0
11.0	-6	-6	0	350.0
10.0	9	0	-15	200.0
12.0	-9	-15	-15	800.0
15.0	15	0	-15	800.0

10.0	6	-15	-15	100.0
10.0	9	6	10	100.0
10.0	15	9	15	100.0
10.0	3	-6	15	350.0
15.0	3	-3	-15	1000.0
15.0	3	-6	15	100.0
10.0	15	0	15	1000.0
15.0	15	0	0	1000.0
11.0	15	15	-10	350.0
13.0	15	-9	15	200.0
12.0	0	-9	-15	100.0
15.0	-12	15	15	800.0
10.0	3	0	5	100.0
15.0	-9	-12	-15	100.0
10.0	-9	-6	-15	1000.0
13.0	-9	15	15	650.0
13.0	-12	-12	15	100.0
12.0	-6	-12	15	500.0
15.0	-9	15	-15	100.0
10.0	0	-15	5	800.0
15.0	15	-15	-10	500.0
11.0	15	-15	0	200.0
10.0	15	-15	0	1000.0
15.0	15	3	15	100.0
13.0	-3	-15	10	200.0
10.0	-9	15	-15	100.0
10.0	0	6	-15	1000.0
10.0	15	15	0	800.0
13.0	-15	15	15	100.0
15.0	9	-9	15	350.0
15.0	9	15	-5	1000.0
13.0	3	15	10	1000.0
15.0	-15	0	-15	500.0
15.0	-9	6	5	1000.0
15.0	-15	0	15	500.0
15.0	15	3	15	650.0

15.0	6	0	-10	800.0
15.0	-6	0	-15	1000.0
15.0	-12	-6	5	1000.0
15.0	15	-3	-15	1000.0
15.0	15	-3	15	200.0
15.0	-15	-15	15	1000.0
15.0	-15	6	5	800.0
15.0	-15	15	15	1000.0
15.0	-3	0	15	1000.0
15.0	-9	-3	-15	1000.0
12.0	-15	0	15	1000.0
15.0	12	9	-15	1000.0
15.0	12	3	5	1000.0
15.0	-9	3	-10	1000.0
15.0	-15	-3	-15	1000.0
15.0	-15	-9	15	1000.0
12.0	-9	3	-15	1000.0
15.0	-6	3	15	1000.0
15.0	-9	0	10	800.0
15.0	-15	15	-15	1000.0
15.0	-15	12	-15	200.0
15.0	-15	0	15	100.0
15.0	-15	9	15	1000.0
13.0	-15	-3	15	1000.0
10.0	-15	0	15	1000.0
15.0	-15	-6	15	800.0
15.0	-9	-3	15	100.0
13.0	-15	3	-15	1000.0
15.0	-15	-6	15	100.0
15.0	9	0	-5	1000.0
15.0	-15	6	-15	1000.0
15.0	-15	-3	15	800.0
15.0	-12	-15	-15	350.0
15.0	-15	-15	0	800.0
15.0	-3	3	-15	1000.0
15.0	-15	-6	15	1000.0
15.0	0	6	-15	800.0
15.0	-9	0	-15	650.0

Job:sub32

Net:sub32

Speed	Stern	Rudder	Fwd	Hold-Time
15.0	-15	0	15	1000.0
15.0	15	0	-15	1000.0
15.0	-15	0	-15	1000.0
15.0	15	0	15	1000.0
15.0	15	0	-15	100.0
15.0	-15	0	15	100.0
15.0	-15	3	-15	100.0
15.0	15	15	15	100.0
10.0	-3	-15	-15	100.0
10.0	15	15	-15	1000.0
15.0	9	-15	15	500.0
10.0	-3	15	15	100.0
10.0	9	-15	0	100.0
15.0	3	15	10	500.0
15.0	15	0	15	500.0
10.0	15	15	-15	100.0
10.0	-15	15	-15	100.0
10.0	15	-15	15	650.0
10.0	-15	-15	15	1000.0
15.0	3	-15	-15	500.0
15.0	15	0	-15	200.0
10.0	15	-12	15	100.0
15.0	-15	-15	15	100.0
11.0	3	15	15	800.0
10.0	15	0	10	650.0
12.0	-3	0	-15	500.0
10.0	-9	-12	15	350.0
15.0	-15	15	15	100.0
11.0	-3	-9	5	500.0

11.0	15	0	-15	500.0
15.0	15	15	15	500.0
10.0	-15	15	15	1000.0
13.0	15	-15	-15	350.0
10.0	9	6	-15	350.0
12.0	-15	3	15	200.0
15.0	12	-15	15	100.0
12.0	15	-15	-15	100.0
15.0	15	12	15	800.0
15.0	-6	15	-15	1000.0
10.0	-15	-15	15	100.0
15.0	15	-15	-15	500.0
13.0	15	0	15	800.0
15.0	12	-15	-15	1000.0
15.0	15	0	15	200.0
15.0	6	15	-15	100.0
15.0	-12	-15	15	800.0
15.0	9	-6	15	100.0
10.0	-15	3	15	800.0
13.0	-3	-15	-15	350.0
15.0	9	6	-15	800.0
10.0	6	15	0	1000.0
15.0	-15	12	-15	200.0
13.0	-15	15	15	100.0
10.0	15	12	15	350.0
15.0	-15	12	15	500.0
15.0	-3	15	15	100.0
15.0	-12	-6	15	200.0
15.0	-15	-15	-15	100.0
13.0	15	-9	15	1000.0
10.0	-15	15	-15	500.0
10.0	9	-15	10	1000.0
10.0	-15	-12	-15	200.0
13.0	0	3	-15	1000.0
10.0	15	-6	-15	100.0
15.0	6	-15	15	1000.0

15.0	-15	12	15	200.0
15.0	3	0	15	1000.0
11.0	15	0	-15	1000.0
10.0	-15	-15	-15	500.0
15.0	12	-6	-10	650.0
10.0	0	0	15	100.0
10.0	15	15	15	500.0
15.0	15	0	-15	500.0
11.0	-3	15	-15	800.0
15.0	0	-12	-15	100.0
10.0	3	0	15	650.0
11.0	-15	-3	-10	500.0
10.0	3	-9	-15	1000.0
15.0	9	3	15	100.0
10.0	0	15	5	500.0
12.0	-6	12	-15	650.0
15.0	15	-9	5	200.0
15.0	3	-6	-15	800.0
12.0	-15	-3	-15	350.0
12.0	3	-6	15	100.0
10.0	3	15	-15	500.0
12.0	-6	12	15	500.0
10.0	15	3	15	200.0
15.0	-9	6	-15	650.0
15.0	-3	-6	-15	350.0
10.0	-3	3	-15	650.0
10.0	-6	15	5	1000.0
10.0	-15	-15	-15	100.0
11.0	-3	0	15	1000.0
10.0	-6	-15	15	650.0
15.0	15	3	15	1000.0
15.0	-15	3	15	800.0
10.0	3	-6	15	800.0
15.0	6	0	15	500.0
10.0	-9	3	-15	200.0
10.0	3	-15	15	200.0

13.0	15	-9	15	350.0
10.0	6	0	10	1000.0
15.0	-15	-15	-15	1000.0
15.0	-15	-3	-15	500.0
10.0	-12	9	15	650.0
12.0	3	9	15	350.0
11.0	0	-6	-15	100.0
10.0	15	-9	15	1000.0
15.0	-3	-15	5	100.0
13.0	-15	-6	15	500.0
15.0	-15	6	15	800.0
12.0	-9	3	-10	1000.0
12.0	15	6	-10	800.0
15.0	12	-3	0	800.0
11.0	-6	6	15	1000.0
15.0	-12	9	15	800.0
11.0	-9	-12	-10	1000.0
10.0	-15	12	-15	1000.0
10.0	15	-15	-5	350.0
10.0	12	-12	-15	100.0
15.0	-3	3	-5	100.0
15.0	15	6	15	100.0
10.0	-15	15	15	100.0
11.0	-9	-15	-10	200.0
10.0	15	-15	-5	800.0
15.0	3	-15	15	100.0
10.0	15	-3	15	100.0
13.0	15	-3	-15	1000.0
10.0	15	-6	-15	800.0
15.0	0	0	-15	800.0
13.0	12	9	-15	350.0
15.0	-6	-9	-10	1000.0
11.0	-15	-15	-5	800.0
10.0	-15	-9	10	200.0
10.0	3	-15	-5	500.0
15.0	-15	12	-15	100.0
10.0	0	-12	0	800.0
10.0	12	6	5	800.0
15.0	15	-3	5	100.0
15.0	6	-3	15	350.0
12.0	6	-15	-5	1000.0
10.0	0	15	-15	100.0
10.0	-15	9	10	200.0
15.0	6	-6	15	200.0
15.0	-9	-9	5	1000.0
15.0	-3	-6	-15	800.0
10.0	-12	15	0	350.0
12.0	0	3	5	800.0
12.0	0	6	15	100.0
15.0	-6	0	-15	350.0
15.0	15	15	-15	650.0
12.0	15	-6	-15	1000.0
15.0	-3	-12	15	650.0
10.0	3	-15	-15	650.0
15.0	-15	-15	5	200.0
11.0	-12	-12	-5	100.0
12.0	-3	-6	-10	1000.0
10.0	-9	3	-15	1000.0
15.0	6	3	-15	800.0
10.0	15	15	15	100.0
10.0	-15	9	-15	100.0
12.0	-15	6	5	500.0
10.0	-12	-12	5	650.0
11.0	15	0	10	1000.0
10.0	-12	0	5	1000.0
13.0	-9	-12	-5	100.0
10.0	-15	3	-15	1000.0
13.0	15	15	15	1000.0
15.0	-6	-3	-5	1000.0
15.0	15	-15	15	1000.0
15.0	-9	-15	15	1000.0
13.0	15	3	-15	800.0

12.0	-15	-15	15	100.0
10.0	15	-6	10	650.0
10.0	9	-3	-15	100.0
10.0	15	3	15	1000.0
10.0	6	0	-15	800.0
15.0	3	-3	-5	1000.0
11.0	15	9	15	800.0
15.0	-12	6	-5	1000.0
13.0	6	0	-15	1000.0
12.0	15	15	10	350.0
13.0	15	-15	5	100.0
13.0	12	-15	-15	100.0
13.0	3	12	15	1000.0
15.0	0	-6	5	1000.0
12.0	15	-12	-5	100.0
13.0	15	0	-15	350.0
10.0	12	-3	-15	650.0
13.0	-9	-9	15	1000.0
15.0	-15	-3	0	800.0
15.0	6	0	-15	100.0
10.0	0	-9	-15	350.0
13.0	0	-15	15	800.0
15.0	15	-3	-10	350.0
15.0	6	0	-15	350.0
10.0	3	-12	15	800.0
11.0	-9	-15	5	350.0
10.0	-15	6	15	1000.0
15.0	-15	-15	15	800.0
12.0	-15	-3	10	1000.0
13.0	9	-9	-15	650.0
12.0	15	-3	15	650.0
12.0	15	6	10	100.0
15.0	-15	12	-15	800.0
13.0	6	0	-15	650.0
11.0	0	0	-15	1000.0
15.0	-15	-9	15	1000.0
15.0	-9	0	15	650.0
10.0	3	-3	-15	350.0
15.0	-9	-12	-15	200.0
10.0	-15	-12	15	650.0
10.0	-15	-3	15	1000.0
13.0	-3	-6	-15	1000.0
15.0	0	-12	-5	350.0
11.0	-6	-12	15	500.0
13.0	9	-3	-15	1000.0
13.0	-15	-6	15	1000.0
15.0	-9	15	-15	500.0
15.0	-12	9	-15	100.0
15.0	-6	9	15	350.0
10.0	-15	3	-15	100.0
15.0	-15	12	15	1000.0
15.0	-15	3	5	800.0
12.0	9	9	15	500.0
12.0	15	-12	15	800.0
12.0	3	-3	-15	500.0
10.0	15	9	-15	200.0
11.0	-9	-15	15	100.0
15.0	0	9	-15	350.0
10.0	6	3	15	350.0
10.0	15	-15	-15	200.0
12.0	12	-15	-15	1000.0
15.0	-3	-12	-10	1000.0
13.0	-12	-15	-5	350.0
15.0	6	-9	-15	1000.0
10.0	9	15	15	200.0
10.0	15	6	-15	100.0
15.0	-9	-15	-15	200.0
10.0	-9	15	-15	650.0
10.0	9	-3	-15	1000.0
15.0	15	15	-15	1000.0
15.0	-15	-12	-15	350.0
10.0	3	6	-10	650.0

15.0	0	15	-5	1000.0
15.0	15	-15	-5	1000.0
15.0	-12	15	-5	100.0

Job:sub33

Net:sub33

Speed	Stern	Rudder	Fwd	Hold-Time
15.0	-15	15	15	1000.0
15.0	-15	-15	15	1000.0
15.0	15	-3	-15	1000.0
15.0	15	3	-15	1000.0
10.0	-15	15	-15	100.0
10.0	-15	-15	-15	100.0
15.0	-15	15	15	100.0
15.0	15	-15	15	100.0
10.0	15	-3	15	100.0
10.0	-15	-3	-5	100.0
10.0	15	-3	15	650.0
10.0	-15	9	0	350.0
15.0	9	-3	-15	100.0
15.0	15	15	15	100.0
13.0	12	3	-15	100.0
13.0	-15	-6	15	200.0
15.0	-15	3	10	100.0
15.0	-15	-15	-15	350.0
13.0	9	9	15	100.0
10.0	15	15	15	100.0
10.0	-15	9	-15	800.0
15.0	-15	9	10	100.0
10.0	15	6	15	100.0
15.0	-15	3	15	1000.0
15.0	-15	-3	15	1000.0
15.0	-12	6	-15	650.0
10.0	-15	-3	-15	650.0
10.0	15	9	-15	100.0
10.0	-15	12	15	200.0
15.0	15	12	-15	100.0
10.0	-15	3	0	1000.0
15.0	-15	-6	-15	350.0
11.0	15	3	-15	100.0
15.0	0	-9	-15	100.0
15.0	15	0	15	350.0
10.0	15	3	15	1000.0
15.0	-6	-12	0	100.0
10.0	-15	-12	-15	650.0
10.0	15	-9	-15	100.0
15.0	15	-9	15	100.0
15.0	-15	12	-15	350.0
10.0	15	-15	-15	350.0
15.0	-15	-15	15	100.0
15.0	15	-9	10	350.0
10.0	-15	-9	-5	1000.0
10.0	-15	12	-15	100.0
15.0	15	-3	-15	800.0
13.0	-3	-12	15	500.0
15.0	0	-15	-15	100.0
12.0	-15	-6	-15	100.0
13.0	-15	-6	15	500.0
15.0	-9	-6	-15	1000.0
15.0	12	-6	-15	350.0
10.0	-15	3	0	350.0
10.0	-15	15	-15	500.0
15.0	12	15	-15	100.0
15.0	15	6	-15	100.0
12.0	15	-15	15	100.0
10.0	-9	15	15	650.0
12.0	15	-3	-15	800.0
15.0	-15	-6	-10	500.0
15.0	15	3	15	1000.0
10.0	0	-15	-15	200.0
15.0	-9	15	-5	100.0

10.0	-15	15	15	100.0	15.0	-15	0	-15	1000.0
15.0	-12	3	15	500.0	15.0	-15	-12	10	500.0
10.0	0	12	15	200.0	15.0	3	-12	-15	650.0
10.0	12	9	0	650.0	15.0	-6	-3	0	1000.0
15.0	-15	-3	0	200.0	13.0	15	-3	10	1000.0
15.0	-12	0	-15	800.0	10.0	0	12	15	800.0
10.0	-15	0	-15	100.0	13.0	15	3	15	1000.0
13.0	-15	-15	-15	100.0	15.0	-15	-15	-15	800.0
15.0	15	-6	0	350.0	13.0	9	-12	-15	100.0
10.0	-15	-15	5	650.0	15.0	-15	-9	-15	100.0
10.0	-15	-9	-15	1000.0	15.0	-15	-6	15	650.0
13.0	-3	9	-15	100.0	10.0	3	-6	15	100.0
12.0	-15	15	-15	100.0	15.0	9	-15	-15	350.0
10.0	-15	3	-15	1000.0	13.0	15	-12	15	200.0
13.0	-3	-12	-15	200.0	13.0	0	-15	-15	100.0
15.0	15	-15	0	500.0	10.0	-15	-15	15	100.0
12.0	-12	6	10	650.0	15.0	-9	0	-10	1000.0
15.0	-15	3	-5	100.0	11.0	-6	-12	10	350.0
15.0	15	-3	-5	650.0	10.0	15	-15	-15	100.0
10.0	-15	6	15	1000.0	15.0	-15	-3	-5	1000.0
11.0	15	-3	-10	350.0	15.0	3	-3	-15	1000.0
15.0	15	3	15	100.0	15.0	15	-12	0	200.0
15.0	15	-3	15	1000.0	13.0	15	-6	-15	100.0
10.0	-15	-9	0	100.0	10.0	-3	6	15	100.0
10.0	12	-12	15	200.0	15.0	15	-12	5	500.0
10.0	12	3	-15	650.0	13.0	-15	6	-15	100.0
12.0	-15	-12	-15	100.0	15.0	15	9	15	100.0
15.0	-9	-3	-10	650.0	15.0	-15	6	15	1000.0
13.0	-9	3	-5	1000.0	13.0	0	15	-15	500.0
15.0	-15	-3	-15	200.0	10.0	15	-15	0	500.0
13.0	0	-3	5	350.0	15.0	-6	-9	-15	800.0
15.0	6	12	15	200.0	15.0	-15	12	15	100.0
15.0	0	-12	-15	350.0	15.0	-15	-15	-5	350.0
11.0	15	-12	0	800.0	10.0	0	0	-15	100.0
11.0	-3	3	15	500.0	11.0	0	-6	-15	1000.0
12.0	-15	-3	15	1000.0	15.0	15	-6	15	100.0

15.0	15	-9	-10	350.0
11.0	9	-6	-15	800.0
13.0	-9	6	-5	[illegible]
10.0	-15	9	-15	500.0
15.0	-15	-15	-10	1000.0
15.0	-15	-9	10	1000.0
15.0	-12	3	-15	350.0
10.0	-6	0	0	100.0
12.0	-9	12	10	100.0
12.0	-9	-3	-10	100.0
15.0	-15	-3	-15	500.0
13.0	-3	-6	-10	1000.0
15.0	15	0	-15	1000.0
12.0	15	-3	15	200.0
10.0	6	-12	-10	650.0
15.0	-15	-6	0	1000.0
13.0	15	6	15	350.0
11.0	-15	-9	-15	650.0
10.0	3	3	-15	350.0
15.0	-15	9	-5	500.0
10.0	15	12	15	100.0
15.0	-15	15	-15	350.0
12.0	-15	3	10	650.0
15.0	15	15	-15	1000.0
12.0	-3	6	5	200.0
11.0	12	-9	-15	500.0
10.0	-12	-12	-15	1000.0
11.0	-6	15	-15	200.0
15.0	-3	3	0	500.0
11.0	-15	12	15	100.0
12.0	-12	15	15	100.0
15.0	-15	-12	15	1000.0
15.0	-15	9	15	1000.0
15.0	15	-3	15	100.0
15.0	15	-12	-15	100.0
10.0	-15	0	15	100.0

10.0	15	-3	15	800.0
10.0	-3	-6	10	1000.0
13.0	-9	-6	5	200.0
13.0	15	-3	0	650.0
10.0	-6	0	-15	650.0
15.0	12	-12	15	100.0
12.0	15	12	15	500.0
12.0	-15	3	-15	100.0
11.0	-6	-9	15	100.0
15.0	-9	0	-15	100.0
13.0	15	6	10	100.0
15.0	-15	9	15	350.0
10.0	-6	-15	-10	650.0
10.0	0	-3	-15	100.0
11.0	-6	0	10	200.0
15.0	15	-15	-10	100.0
10.0	3	3	15	100.0
13.0	15	15	15	100.0
15.0	9	12	5	100.0
10.0	3	3	-15	1000.0
10.0	15	-6	-15	100.0
12.0	-12	9	-5	500.0
13.0	-15	0	0	350.0
10.0	15	0	15	200.0
10.0	15	-3	-15	800.0
13.0	-9	3	0	100.0
15.0	-6	0	15	100.0
10.0	-15	0	-10	1000.0
15.0	-15	12	-5	100.0
13.0	6	-6	-15	1000.0
11.0	-12	-3	10	100.0
15.0	-3	0	15	200.0
12.0	-12	0	-10	500.0
15.0	3	6	15	100.0
10.0	-12	6	0	100.0
15.0	-15	-9	-15	500.0

10.0	-15	-6	15	350.0
10.0	6	0	10	100.0
11.0	-15	-12	15	100.0
10.0	12	-3	15	1000.0
11.0	-15	-15	-15	800.0
11.0	12	-3	-15	800.0
10.0	0	-6	-15	100.0
12.0	-9	-9	-15	1000.0
10.0	9	-9	-15	650.0
10.0	12	15	-15	100.0
13.0	-3	0	10	100.0
10.0	0	-15	0	500.0
15.0	-15	9	-15	1000.0
15.0	-15	15	5	100.0
15.0	-15	-6	15	1000.0
15.0	-9	3	-15	1000.0
15.0	-15	9	-10	1000.0
13.0	3	15	-5	100.0
15.0	3	-6	-10	1000.0
15.0	-9	0	-5	100.0
13.0	-9	12	-10	200.0
15.0	-3	-3	15	350.0
10.0	-9	6	-15	1000.0
15.0	-15	-3	5	350.0
12.0	6	-15	5	100.0
10.0	12	6	15	1000.0
12.0	-15	-12	-15	1000.0
15.0	12	6	-5	100.0
10.0	15	0	-5	1000.0
11.0	15	-12	-10	100.0
12.0	12	6	-15	1000.0
10.0	-12	0	-15	500.0
15.0	15	0	15	1000.0
15.0	-15	-12	-10	1000.0
10.0	-15	-3	10	100.0
12.0	-9	3	15	1000.0

15.0	-15	0	15	500.0
12.0	12	0	-15	100.0
15.0	0	-3	10	500.0
10.0	-15	-12	15	1000.0
10.0	-15	-3	5	1000.0
10.0	15	9	15	800.0
15.0	-12	0	0	100.0
10.0	-3	-9	10	650.0
10.0	-9	-9	5	1000.0
10.0	-15	0	-5	500.0
11.0	-9	0	15	100.0
15.0	-15	-3	10	100.0
15.0	-15	12	-15	650.0
13.0	-15	6	-5	1000.0
15.0	12	15	5	500.0
10.0	0	15	0	200.0
15.0	-3	12	10	100.0
10.0	-6	-3	15	650.0
13.0	3	0	-15	1000.0
15.0	-15	3	15	650.0
15.0	15	0	-10	100.0
11.0	15	6	-15	100.0
10.0	-6	15	0	1000.0
15.0	-3	12	15	100.0
15.0	0	9	5	200.0
13.0	15	9	5	100.0
15.0	15	0	-15	800.0
12.0	15	3	-10	1000.0
10.0	-15	15	-15	1000.0
10.0	6	-9	0	650.0
13.0	12	-12	-15	100.0
13.0	-15	0	-15	100.0
15.0	15	3	-10	1000.0
15.0	0	6	-10	1000.0
15.0	15	-9	-15	100.0
15.0	9	15	-15	350.0

15.0	-15	9	-15	100.0
10.0	12	-3	-15	100.0
10.0	6	6	-15	100.0
12.0	3	6	15	200.0
10.0	12	9	0	100.0
10.0	15	3	0	200.0
11.0	-12	15	15	200.0
13.0	-15	0	15	100.0
11.0	3	9	5	200.0
11.0	12	0	15	100.0
11.0	3	15	-15	100.0
15.0	-9	3	-5	1000.0
13.0	3	6	-15	1000.0
15.0	-15	-6	15	100.0
10.0	3	-9	15	800.0
15.0	-3	9	15	100.0
10.0	15	15	10	350.0
12.0	15	9	15	500.0
12.0	3	-15	5	200.0
15.0	6	-12	0	350.0
10.0	6	12	10	100.0
15.0	-15	0	-10	800.0
15.0	-9	-3	-15	1000.0
10.0	-6	12	-10	200.0
15.0	15	-9	-15	200.0
15.0	15	-9	15	350.0
12.0	3	12	-10	100.0
13.0	9	0	-15	1000.0
15.0	9	3	10	500.0
13.0	6	3	-15	1000.0
10.0	12	-12	10	100.0
12.0	15	6	15	100.0
13.0	15	0	-5	1000.0
10.0	-12	-15	-5	350.0
15.0	-15	3	15	100.0
15.0	9	3	-10	1000.0

11.0	15	-12	10	100.0
15.0	15	6	15	500.0
10.0	0	-9	-10	650.0
15.0	3	-9	0	650.0
10.0	15	9	15	100.0
15.0	9	0	-15	1000.0
15.0	15	12	10	200.0
11.0	15	-9	15	350.0
15.0	-15	9	-5	1000.0
15.0	-15	12	15	1000.0
10.0	-15	-15	-15	650.0
15.0	-15	15	-15	500.0
10.0	15	12	-15	200.0
12.0	9	15	10	100.0
10.0	6	-15	-15	100.0
12.0	15	-12	0	100.0
15.0	-15	6	15	100.0
13.0	-15	12	5	1000.0
10.0	6	9	-15	800.0
15.0	-3	12	-15	800.0
11.0	12	12	-10	200.0
10.0	9	-15	5	100.0
10.0	-15	-6	-10	100.0
10.0	-15	-15	-10	1000.0
11.0	-15	0	-15	1000.0
13.0	6	-3	15	350.0
15.0	15	6	0	650.0
10.0	12	-6	15	1000.0
15.0	15	-9	-15	1000.0
15.0	-3	-3	15	200.0
13.0	-3	-9	-5	1000.0
12.0	-15	0	15	1000.0
15.0	12	3	10	800.0
15.0	15	-15	-15	800.0
15.0	12	-3	10	200.0
13.0	-9	-3	-15	1000.0

15.0	15	-3	10	100.0
13.0	6	-15	15	200.0
10.0	15	-12	10	350.0
15.0	15	-6	-10	650.0
15.0	15	-6	5	100.0
15.0	-6	-3	15	100.0
12.0	6	-9	-5	650.0
10.0	15	-15	5	200.0
12.0	15	12	15	200.0
15.0	9	-3	15	100.0
15.0	15	-3	0	1000.0
10.0	9	-3	-15	1000.0
10.0	15	-15	5	350.0
10.0	6	12	-15	1000.0
12.0	-9	-15	-15	500.0
12.0	15	-15	-10	100.0
15.0	6	6	15	1000.0
15.0	12	-9	15	650.0
15.0	-15	9	15	800.0
11.0	3	-9	-15	650.0
13.0	-15	0	-15	650.0
15.0	-15	-9	-5	1000.0
15.0	-15	3	-15	500.0
10.0	-15	9	15	650.0
13.0	-15	6	-15	650.0
13.0	-15	15	0	200.0
13.0	6	3	15	1000.0
12.0	-15	0	-10	1000.0
15.0	15	15	-5	200.0
15.0	-15	3	-5	1000.0
13.0	12	15	10	350.0
10.0	-15	-9	-15	100.0
12.0	-9	9	-15	500.0
15.0	-15	15	-10	800.0
15.0	-6	6	-15	1000.0
10.0	-15	12	-10	1000.0
15.0	-6	6	-10	1000.0
12.0	-15	-3	-10	1000.0
15.0	-6	3	5	1000.0
15.0	15	6	-15	1000.0
11.0	-15	-6	-15	1000.0
12.0	3	12	15	100.0
13.0	-6	-3	-5	1000.0
15.0	-15	6	-15	350.0
10.0	15	-3	-15	1000.0
12.0	-9	0	-15	1000.0
10.0	-15	-3	-15	200.0
10.0	-12	-6	-15	200.0
15.0	0	3	-15	1000.0
13.0	6	15	5	200.0
13.0	-12	15	0	500.0
15.0	0	12	-15	1000.0
15.0	-15	15	-15	650.0
13.0	12	15	5	200.0
11.0	9	-3	-15	100.0
12.0	-3	15	-15	650.0
10.0	15	0	-15	500.0
15.0	3	-9	-15	650.0
12.0	-6	15	-15	500.0
11.0	15	15	-10	650.0
15.0	-15	-12	0	1000.0
10.0	15	-15	15	350.0
13.0	9	-3	15	200.0
10.0	-15	-15	15	350.0
13.0	-15	15	0	350.0
12.0	-12	15	-15	800.0
11.0	6	-3	-10	100.0
10.0	-3	12	15	650.0
12.0	0	-3	-15	100.0
15.0	15	12	15	1000.0
15.0	-3	15	10	100.0
10.0	-12	-3	-15	1000.0

15.0	15	0	15	800.0
10.0	6	-3	-10	1000.0
10.0	-9	-6	-15	500.0
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15.0	-15	12	-15	1000.0
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11.0	12	15	-10	350.0
10.0	-3	9	15	200.0
10.0	-15	6	-15	650.0
10.0	15	12	-5	100.0
11.0	15	15	-5	350.0
10.0	-3	-3	-15	650.0
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13.0	15	-15	-15	200.0
10.0	15	-12	-15	350.0
15.0	-6	0	-15	800.0
13.0	-12	-12	-15	650.0
10.0	3	-12	-15	100.0
11.0	-3	9	0	1000.0
15.0	-15	9	15	650.0
10.0	-15	-9	15	200.0
10.0	-15	12	-15	1000.0
11.0	15	12	10	650.0
10.0	-15	-6	-15	100.0
15.0	3	15	15	200.0
12.0	-9	9	-15	1000.0
11.0	-15	6	-15	800.0
10.0	15	-15	-15	200.0
10.0	0	12	-15	650.0
10.0	-6	-15	-15	350.0
10.0	-15	-6	-15	650.0
12.0	-15	15	-15	1000.0
11.0	-15	-6	-15	800.0
15.0	15	15	0	100.0
13.0	15	-15	-15	100.0
10.0	-15	-9	-15	650.0
10.0	-15	6	15	100.0
11.0	-3	-9	-10	500.0
11.0	-15	-6	-10	650.0
15.0	0	-3	-10	1000.0
15.0	-15	15	-5	650.0
12.0	-6	-15	15	200.0
10.0	15	12	10	350.0
10.0	15	9	15	1000.0
10.0	15	3	15	100.0
11.0	-15	3	-15	800.0
10.0	15	-3	-15	100.0
15.0	15	3	-15	800.0
15.0	-15	0	15	800.0
10.0	15	-15	-15	1000.0
15.0	15	-15	15	500.0
15.0	15	-3	-15	650.0
15.0	12	15	-15	500.0
15.0	-12	-3	15	1000.0
15.0	15	-3	15	800.0
15.0	15	0	-5	800.0
15.0	-9	3	15	1000.0
15.0	15	9	-10	650.0
15.0	-6	9	15	1000.0

Job:sub34

Net:sub34

Speed	Stern	Rudder	Fwd	Hold-Time
15.0	-15	3	15	1000.0
15.0	-15	-3	15	1000.0
15.0	-15	-15	15	100.0
15.0	15	0	-15	1000.0
10.0	-15	-15	-15	500.0
15.0	15	-15	15	650.0

12.0	15	-3	15	800.0
13.0	6	-3	-10	350.0
10.0	-12	-15	5	800.0
12.0	-15	-3	15	1000.0
15.0	-15	0	-15	1000.0
13.0	-15	-6	15	200.0
11.0	12	15	-15	100.0
11.0	-12	15	-15	100.0
15.0	12	15	15	650.0
15.0	-15	-15	15	800.0
12.0	6	-6	-15	1000.0
10.0	15	-6	15	100.0
15.0	-15	0	15	1000.0
10.0	12	12	-15	1000.0
15.0	15	3	15	1000.0
15.0	0	0	-15	1000.0
15.0	-15	-6	15	650.0
15.0	15	-6	-15	100.0
15.0	-15	3	0	800.0
13.0	-15	0	-15	500.0
10.0	-6	0	15	100.0
15.0	-6	0	15	1000.0
10.0	-15	-6	-15	350.0
15.0	15	-3	15	1000.0
11.0	-15	0	15	1000.0
11.0	15	6	-10	1000.0
10.0	3	-3	-5	100.0
10.0	-15	3	15	100.0
15.0	-9	3	15	1000.0
15.0	-15	6	15	1000.0
15.0	-15	0	15	650.0
15.0	15	6	-15	100.0
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15.0	-6	-3	-15	100.0
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11.0	-15	-9	15	1000.0
15.0	-15	-3	-15	1000.0
15.0	3	-15	-15	1000.0
10.0	12	9	15	500.0
10.0	15	3	-15	100.0
15.0	-15	-3	15	800.0
15.0	-9	-6	-15	1000.0
15.0	-12	0	15	1000.0
15.0	-15	-6	-15	200.0
15.0	6	-3	15	100.0
15.0	15	-15	15	200.0
15.0	-6	-6	10	650.0
15.0	-9	-3	15	1000.0
15.0	15	-9	-15	1000.0
13.0	-15	3	15	1000.0
15.0	15	-3	-15	800.0
15.0	12	-3	0	100.0
10.0	-15	0	5	350.0
10.0	12	-9	-15	350.0
11.0	-6	-3	-15	350.0
15.0	-12	-3	10	1000.0
15.0	-15	-6	-5	1000.0
15.0	-15	3	5	1000.0
10.0	15	3	15	800.0
15.0	-15	-15	-15	650.0
13.0	-15	0	10	500.0
15.0	-15	15	15	500.0
13.0	3	3	0	1000.0
15.0	-15	6	15	800.0
15.0	-15	0	5	800.0
12.0	-15	-12	-15	800.0
15.0	-15	15	-15	800.0
10.0	15	3	-15	800.0
10.0	-15	3	-15	1000.0
15.0	15	-15	-15	100.0

10.0	-15	-9	-15	100.0
15.0	-15	-6	15	1000.0
13.0	-15	-12	15	800.0
15.0	-15	-3	15	650.0
15.0	-9	-9	5	800.0
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10.0	-15	-15	15	200.0
12.0	6	-12	15	650.0
15.0	15	-3	15	500.0
13.0	15	0	-10	1000.0
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15.0	-9	-9	15	1000.0
13.0	-12	-15	-15	800.0
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15.0	15	-9	-15	100.0
13.0	-12	0	15	800.0
15.0	15	0	15	1000.0
15.0	-15	3	15	800.0
10.0	9	-15	15	350.0
11.0	-15	-15	-10	1000.0
13.0	-6	6	15	100.0
15.0	-15	-12	-5	500.0
15.0	15	0	15	500.0
15.0	-15	-12	-15	1000.0
10.0	-12	-15	-10	100.0
15.0	-15	0	5	1000.0
15.0	15	-15	-10	650.0
15.0	-15	3	-15	1000.0
15.0	-15	-3	0	100.0
15.0	-9	-15	-5	1000.0
10.0	15	-15	15	1000.0
13.0	-15	-6	15	1000.0
15.0	15	-9	15	350.0
12.0	15	0	15	100.0
13.0	9	-15	15	350.0
15.0	-15	15	15	1000.0
13.0	-15	0	15	1000.0
10.0	-15	0	5	1000.0
13.0	-15	-15	-5	1000.0
15.0	-15	-12	15	650.0
15.0	3	-9	-10	350.0
13.0	-6	-12	-15	100.0
15.0	-12	-6	15	800.0
10.0	-15	0	-10	100.0
15.0	-15	15	10	800.0
13.0	-15	-12	10	1000.0
15.0	-9	3	-15	650.0
11.0	-15	-15	15	1000.0
10.0	-15	-9	-10	650.0
15.0	15	-9	-15	800.0
15.0	15	-3	-15	1000.0
15.0	-15	-3	5	1000.0

10.0	15	-6	10	1000.0
15.0	-12	-3	15	1000.0
15.0	0	-3	15	800.0
15.0	-15	-12	15	1000.0
10.0	-15	15	-15	650.0
13.0	-15	-9	15	1000.0
15.0	-15	12	0	800.0
10.0	-12	-6	15	800.0
10.0	-15	-3	15	350.0
15.0	15	-12	10	1000.0
15.0	-3	-3	10	350.0
15.0	15	6	-15	350.0
15.0	-15	-6	0	100.0
15.0	-9	-15	15	500.0
15.0	-15	15	5	100.0
15.0	-9	-15	10	1000.0
15.0	15	6	15	350.0
15.0	-12	-9	-5	1000.0
15.0	-6	-15	-15	350.0
15.0	15	-6	-15	350.0
15.0	-15	-3	10	800.0

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Prepared by:
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13. ABSTRACT (Maximum 200 words)

This document is the final report for ARPA contract MDA972-93-C-0044, which is to develop an ANS (Artificial Neural System) capable of modeling submarine performance based on full scale data generated using a computer based simulation program.

This report discusses the project background, including the requirements of such a simulation model, and the advantages of an ANS approach. The uniqueness of AWI's Optimal-Entropy Neural Network algorithm is discussed as well as its significance to the success of this project. AWI has developed an ANS to model submarine performance based on the setting of the input parameters to result in a particular performance for the submarine where the ANS specifies the position and orientation of the submarine sometime in the future. AWI has also developed an algorithm to run the ANS in the inverse mode, namely the algorithm allows the user to specify the desired position and orientation of the submarine at some time in the future, where the ANS will then specify the controlling input parameters to reach that specified objective. The latter specifications have to be within the realm of possible requirements or else the ANS will specify a possible solution close to what was desired. The developed ANS is capable of operating in a PC environment. The results are obtained almost instantaneously on the PC.

14. SUBJECT TERMS
Artificial Neural System, Neural Network, Submarine Simulation Modeling

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